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ABSTRACT

The main aim of this investigation was to re-visit the taxonomy and chromosome cytology of the genera ***Ledebouria*** *and* ***Drimiopsis*** *(Hyacinthaceae) in Ethiopia and to improve the descriptions and classification of the species under the two genera. In the study, morphological data from both vegetative and floral characteristic features were generated and SPSS version 11 was used for data analysis. NTSYS version 2.1 was also used to construct dendrograms based on the overall qualitative and quantitative data. Chromosome cytological features were also studied and chromosomes size and arm ratio measurements were made on enlarged photomicrographs using a computer application micromeasure software version 3:2. The computed cluster analysis based on morphological data revealed that the two genera are distinict morphological groups and almost all the specimens examined for each species of the two genera form independent. But,* ***L. urceolta*** *is closely related to* ***L. revoluta*** *and the cluster analysis does not support recognizing* ***L. urceolata*** *as a separate taxon. Most of the herbarium materials identified as* ***D. botryoides*** *were also found to be very different from the description of the taxon in the Flora (FEE) in both floral and vegetative characteristic features. This calls for further investigations to determine the taxonomic identity of the materials. Chromosome counts for five and two different cytotypes of* ***L. revoluta*** *and* ***L. cordifolia*** *are also presented, respectively. Out of these, five of them represent new chromosome number report:* ***L. cordifolia*** *(2n = 30 and 34) and* ***L. revoluta*** *(2n = 38, 40 and 44). The difference in chromosome number between the two cytotypes of* ***L. cordifolia*** *is accompanied by differences in karyotype and morphological discontinuities. Thus, even though further studies are required, splitting the taxon into two taxa seems reasonable. The difference in chromosome number among different cytotypes of* ***L. revoluta*** *was also accampained by an immense difference in karyotype without showing any morphological differences and discontinuities. No trend in ploidy levels could also be drawn both in the present study and in the studies done so far. Such a difference might also suggest the plants may belong to different biological species. Further studies in the line of chromosome cytology and molecular systamatics might resolve the taxonomic controversy and thus highly recommendable.*

1. INTRODUCTION

1:1 General Overview of the Family and the Genera under Study

The genera *Ledebouria* and *Drimiopsis* belong to the Family Hyacinthaceae. The members of the Family Hyacinthaceae are bulbous herbs with rosette leaves that arise from the apex of the bulb and with spicate or racemose inflorescence at the end of a leafless scape. The Family Hyacinthaceae is related to the Family Alliaceae (the onion family) differring mainly in chemistry and inflorescence type, which is umbel in the latter case (Sebsebe Demissew *et al.* 2003). With regard to their chemical content, members of the Family Hyacinthaceae lack the sulfur compounds that give a particular smell and taste to members of the onion family.

The Family Hyacinthaceae comprises about 40 genera and some 900 species widely distributed in temperate to tropical regions, with the highest species number in South Africa and in a region from the Mediterranean to southwest Asia (Stedje, 1996a). Stedje (1996a) also pointed out the presence of 9 genera and about 31 species in East Africa (Kenya, Uganda and Tanzania). On the other hand, Stedje (1997) indicated the presence of 22 species and seven genera: *Schizobiasis*, *Dipicadi*, *Drimiopsis*, *Ledebouria*, *Drimia*, *Albuca* and *Ornithogalum*, in the Flora of Ethiopia and Eritrea (FEE).

The genus *Drimiopsis* contains about 15 species in Africa south of the Sahara and reaches its northern limit in Ethiopia with two representative species (Sebsebe Demissew *et al*.,

2003). *Ledebouria* also contains more or less equal number of species i.e. 15-20 in Africa and south Asia (Thulin, 1995). In Ethiopia, the presence of six species of *Ledebouria*: *L. somaliensis* (Bak.) Stedje and Thulin, *L. kirkii* (Bak.) Stedje and Thulin, *L. edulis* (Engl.) Stedje, *L. urceolata* Stedje, *L. cordifolia* (Bak.) Stedje and Thulin and *L. revoluta* (L.F.) Jessop and two species of *Drimiopsis* (*D. barteri* Bak. and *D. botryoides* Bak.) have been documented in FEE (Stedje, 1997). In the Flora, *L. urceolata* is treated as endemic plant, which is only known from Gojam, Shoa and Bale. After the publication of FEE, it was discovered that what has been documented as *D. barteri* was another species, *Drimiopsis spicata* (Bak) Sebsebe and Stedje, which is a near endemic species found in western Ethiopia, adjacent to Sudan (Sebsebe Demissew *et al*. 2005).

The genera *Drimiopsis* and *Ledebouria* are mainly recognized from other related genera in the family by their often spotted leaves and few seeded capsules, 1-2 basal ovules per locule resulting in 1-2 globose seeds (Thulin, 1995). But, the two genera can be distinguished from each other by the following traits: The genus *Ledebouria* is diagnosed in having flowers with reflected tepals, purple filaments, sometimes also purplish tepals, stiptate ovary and presence of bracts. In contrast, the genus *Drimiopsis* has flowers with connivent tepals (at least the inner ones), whitish to greenish flowers (including filament), sessile ovary and short pedicels without bracts (Stedje, 1997).

Characteristic features such as length and width of the perianth, length of the pedicel, shape and width of leaves, presence or absence of papillae on the leaves, papillae color, size of the plant and length to width ratio of the perianth segment are used to differentiate

among the species of the genus *Ledebouria* (Thulin, 1995, Stedje, 1996a and 1997). Flower colors and conniventation of the perianth segment are the two diagnostic features that are used to differentiate between *D. spicata* and *D. botryiodes* (Sebsebe Demissew *et al*. 2003).

1.2 General characteristics of the genera *Drimiopsis* and *Ledebouria*

1.2.1 *Drimiopsis* Lindl. And Paxt.

The genus *Drimiopsis* includes glabrous plants that have often spotted leaves that are narrowly or broadly lanceolate with or without pseudopetiole. The genus differs from all other genera in the family in that the flowers are not supported by bracts (Sebsebe Demissew *et al.,* 2003). The flowers are globular to shortly cylindrical, and the three inner tepals are highly connate and appear to be closed, except for small hole where insects with long proboscis may get access to the nectar (Stedje, 1996a; Hankey 2003; Sebsebe Demissew *et al.,* 2003). The tepals are united at base, green to white, blue in *D. spicata* (Sebsebe Demissew *et al*., 2003), and often persistent in fruit. The filaments are flattened and triangular. They have sessile ovaries with 1-2 basal ovules per locule, usually with 1-2 seeds, which are globose to ovoid with a folded black shiny surface according to Stedje (1996a and 1997). The key for the two Ethiopian species of Drimiopsis can be made based on the current existing information as follows.

1. Leaves narrowly lanceolate; perianth segments bluish-purple, both inner and outer connivent at anthesis. 1. *D. spicata*

- Leaves broadly lanceolte; inner perianth segments connivent, outer perianth segments spreading at anthesis. 2. *D. botryides*

1.2.1.1 *D. spicata* (Bak) Sebsebe and Stedje (1995)

This species was first described by Baker in 1878, based on a material from Sudan and was then included in the genus *Scilla* (Sebsebe Demissew *et al.,* 2003). According to Sebsebe Demissew *et al.,* (2003), the species epithet 'spicata' refers to the spicate inflorescence, which is not typical to the genus *Scilla* and as a result Sebsebe and Stedje transferred it to the genus *Drimiopsis*. Unlike other *Drimiopsis* species, this species has a blue flower which is a characteristic feature of *Ledebouria* and as a result the species is considered as the one that probably bridges the two genera, the genera *Ledebouria* and *Drimiopsis* (Sebsebe Demissew *et al.,* 2003).

Sebsebe Demissew *et al.,* (2003), also described *D. spicata* as plants that grow to a height of 15-20 cm; with narrowly lanceolate, *c* 17 cm long and 2 cm wide leaves; with a dense spike inflorescence, having flowers on a very short pedicels and purplish to bluish, 2-2.5 mm long, connivente (both the inner and the outer) tepals. The inner perianth segments are shortly lingulate and usually narrower than the outer. The other Ethiopian species of the genus, *D. barteri* and *D. botryoides* are described by Stedje (1997) as follows:

1.2.1.2 *D. barteri* Bak. (1870)

Plants 15-22 cm long. Leaves lanceolate, *c* 17 x 2 cm. Inflorescence a dense spike. Perianth segments greenish to purplish, *c* 2-2.5 cm long, convented (both the inner and the outer) tepals. The inner perianth segments are shortly lingulate and usually narrower than the outer.

D. barteri was first described in 1870 on a material from Nigeria by Baker (Stedje, 1997). Even though there is no description for filaments, ovary, style, capsule and seeds of Ethiopian *D. barteri*, in Stedje (1997), the taxon is described to have flattened, triangular filaments that are united with the perianth segments at their lower bases; a 1-2 mm long ovary; a slender style almost equivalent in length to the ovary; a capsule that is about 5 mm long and sub-globose seeds that are about 2-4 mm in diameter in Flora of Tropical East Africa (Stedje, 1996a). But, Sebsebe Demissew *et al*., (2005) considered the *D. barteri* in the Flora (FEE) as a synonym of *D. spicata*. The description of *D. spicata* in Sebsebe Demissew *et al*., (2003) also overlaps with the description of *D. barteri* in the Flora (FEE) (Stedje, 1997) differing mainly in flower color.

1.2.1.3 *D. botryoides* Baker (1970)

Plants up to 20 cm long. Leaves lanceolate to broadly lanceolate, *c* 17 x 8 cm. Inflorescence sub-spicate. Pedicel *c* 1mm long. Perianth segments white to greenish white, elliptical, *c* 3 mm long. Outer perianth segments spreading, inner perianth segments erect with connivent tips, usually wider than the outer.

According to Sebsebe Demissew *et al.,* (2003), *D. botryoides* has a dense inflorescence with globose flower and the Greek word 'botryoides' also literally refers to this feature. This species can easily be identified from the other species in the genus by its broad leaves and the spreading outer tepals, leaving the inner ones alone to enclose the rest of the flower parts (Sebsebe Demissew *et al.,* 2003). Unlike in *D. spicata*, in this species, it

is only the inner perianth segments that are connivent at anthesis. The whitish to greenish white tepals can also help in easily separating it from *D. spicata*.

1.2.2 *Ledebouria* Roth (1821)

Plants belonging to this genus have often spotted, cordate to linear, sometimes petiolate leaves with stiff hairs or purple papillae (Stedje, 1997). They also have racemose inflorescence on a glabrouse scape. Unlike plants in the genus *Drimiopsis*, they have minute often shallowly or deeply splitted bracts having a length of about 3 mm (Stedje, 1996a). Their perianth segments are free or united at base, reflexed on the larger part or only at tips, greenish to purple in color (Stedje, 1997). Stedje (1997), in the revision of the genus for FEE clearly indicated that, the plant taxa belonging to this taxon have filaments united with the perianth segments for 0.5-2 mm length; 3-locular stiptate conical or obconical ovaries with two ovules per locule; slender style with minute stigma; an ovoid to sub-globose capsule or sometimes schizocarp and black, sub-glabose seeds. To distiguish the spcies under the genus, the following key is used in FEE (Stedje, 1997).

1. Perianth segments 9 mm or more.	2
- Perianth segments 8 mm or less.	3
2. Pedicels up to 3 mm long.	1. *L. somaliensis*
- Pedicels 5 mm long or above.	2. *L. kirkii*
3. Leaves linear, up to 7 mm wide.	3. *L. edulis*
- Leaves lanceolate to cordate, more than 15 mm wide.	4
4. Perianth segments about 3 mm wide and one to two times longer than wide, only the tips reflex.	4. *L. urceolata*
-Perianth segments 0.8-2 mm wide and longer than two times wide, only tips are reflex	5

5. Leaves cordate to broadly lanceolate, often with purple papillae above. *L. cordifolia*
- Leaves lanceolate, without papillae, but often with purple spots. *L. revoluta*

1.2.2.1 *L. somaliensis* (Baker) Stedje and Thulin (1995)

The species was first described on a material from Somalia in 1892 by Baker and included in the genus *Scilla*. But later on, while revising Hyacinthaceae on the Horn of Africa, Stedje and Thulin transferred it to *Ledebouria* (Stedje and Thulin, 1995). The plant is recognized by its large perianth segments (9 mm or more) and its short pedicel (up to 3 mm long) (Thulin, 1995; Stedje, 1996a and 1997). Stedje (1997), in her revision of the species for Flora of Ethiopia and Eritrea, pointed out that plants belonging to this species grow to about 30 cm height; have lanceolate, *c* 17 x 3 cm leaves; 5-20 cm long inflorescence having about 70 flowers; 1-3 mm long pedicels; green to purple, 9-11 mm long tepals reflexing at anthesis; purplish, 7-9 mm long filaments; ovaries of about 1.5 mm long; styles of about 8 mm long; capsule of about 8 mm long and seeds of about 5 mm in length.

But, East African species of the taxon relatively have wider leaves, which are up to 6 cm wide; shorter inflorescence, up to 9 cm long and smaller number of flowers per inflorescence, about 50 flowers (Stedje, 1996a).

1.2.2.2 *L. kirkii* (Baker) Stedje and Thulin (1995)

The specifc epithet ‘kirkii’ refers to the first collector Kirk, who collected the plant from Zanzibar for the first time (Sebsebe Demissew *et al*., 2003). The plant has longer

perianth segments like *L. somaliensis*. But, unlike *L. somaliensis*, it has got longer pedicels.

The plant grows to a height of 40 cm; have lanceolate leaves; pedicels of about 5-9 mm long; greenish tepals of about 10 mm long, reflexing at anthesis; purple filaments of about 8 mm long and capsules and seeds of similar in nature to that of *L. somaliensis* (Stedje, 1997).

Even though the plant is described to have leaves of about 30 cm long and 12 cm wide having a pseudopetiole of about 6 cm in Flora of Tropical East Africa (Stedje, 1996a), for Flora of Ethiopia and Eritrea the description of leaf length and width is not included. In Flora of Tropical East Africa, the species is also described to grow to 65 cm in height; to have 10-45 cm long inflorescences; 5-16 mm long pedicels and 8-25 mm long perianth segments. This clearly indicates that the East African species have larger floral and vegetative parts.

Hence, this might lead us to suspect the presence of differences at gene and polidy levels. The plants may also be belonging to different biological species and they may also have different taxonomic ranks. So, chromosome cytology works, crossing experiments between the Ethiopian and East African species, molecular analysis and detail morphological studies certainly help to see the taxonomic ranks of them.

1.2.2.3. *L. edulis* (Engl.) Stedje (1995)

Engler described the species as a species in the genus *Scilla* in 1892 based on a material from Sudan and later transferred to *Ledebouria* by Stedje in 1995 (Stedje, 1997)

L. edulis is a small and slender plants, up to 15 cm in length; have linear, *c* 12 cm x 0.7 cm leaves; raceme inflorescences of about 3 cm long; pedicels of about 2 mm long and tepals of about 5 mm long (Stedje, 1997).

For Ethiopian specimens of the species the capsule and seeds are not described yet. But, the species is described to have a subglobose capsule with about three seeds in Flora of Tropical East Africa (Stedje, 1996a). According Stedje (1996a), this species is closely related to *L. revoluta*. But, it differs from *L. revoluta* and other species in the genus by its linear leaves.

1.2.2.4 *L. urceolata* Stedje (1995)

The trival name or epithet 'urceolata' literally means vase to urn-shaped and refers to the shape of their flower (Sebsebe Demissew *et al*., 2003). The plant was described by Stedje in 1995 based on a material from Bale floristic region, Ethiopia (Stedje, 1997). Plants belonging to this species grow to a height of about 30 cm, having lanceolate, *c* 9 cm x 3 cm leaves; inflorescences of about 3-12 cm long having a moderately dense flower, about 50 in number; pedicels that are about 5-10mm long; perianth segments that are about 4-6

mm long and 3 mm wide; filaments that are about 4 mm long; and a capsule of about 5 mm long (Stedje, 1997).

In all other representatives of the genus, the tepals are reflexed for more than half of their length. But, in *L. urceolata*, only the tips are recurved (Sebebe Demissew *et al*., 2003). That is the reason why the plant has got a vase shaped flowers from which the name of the species is derived.

1.2.2.5 *L. cordifolia* (Baker) Stedje and Thulin (1995)

L. cordifolia has cordate leaves that are more or less heart shaped and the species epithet 'cordifolia' itself literally means cordate or heart shaped leaves. The species was first described by Baker based on a material from Malawi, and transferred to the genus *Ledebouria* by Stedje and Thulin in 1995. The plants belonging *L. cordifolia* are little striking plants with one or a few prostrate leaves, clasping the stem, often covered by purple papillae and small flowers (Sebsebe Demssew *et al*., 2003).

Sebsebe Demissew, *et al*., (2003) described the species as composed of plants that grow to 15 cm height; have leaves that are cordate to broadly lanceolate, often petiolate, up to 8 cm long and 4.5 cm wide, covered by purple papillae on the upper surface; inflorescences that are up to 8 cm long having up to 60 flowers; 5-8 mm long pedicels; purplish flowers whose tepals are about 3-4 mm long. But, the tepals and seeds are not included in the descriptions.

Stedje (1996a), in Flora of Tropical East Africa, reported the taxon to have long capsule. Similarly the characteristic feature of seeds of the taxon is not described in this Flora too.

1.2.2.6 *L. revoluta* (L. f.) Jessop (1970)

The species was first described by son of Linnaeus on a material from the Cape region in South Africa in 1872 and grouped to the genus *Hyacinthus*. It is transferred to *Ledebouria* by Jessop in 1870 (Sebsebe Demissew *et al*., 2003).

The plant grows to 9-35 cm height; have leaves that are *c* 18 x 8 cm, often covered with purple spots or lines; 3-10 cm long inflorescence having up to 60 flowers, pedicels that are about 3-12 mm long; greenish to purple flowers with 4-8 mm long tepals and a capsule of about 5 mm long (Stedje, 1997).

1.3 Taxonomic position of *Drimiopsis* and *Ledebouria*

The genus *Drimiopsis* is established with the South African *D. maculata* Lindl. and Paxt. as a type. The first to be discovered from Tropical East Africa were *D. botryoides* and *D. barteri* (Baker, 1870).

Ledebouria has previously mostly been included in the genus *Scilla*; but Jessop reinstated it as a separate genus in 1970. Jessop (1970), splitted the genus *Scilla* into two genera, *Scilla* and *Ledebouria* based on morphological characteristics of South African species. For East African species, Stedje (1996a) distinguished the two genera based on leaf and floral features. The genus *Scilla* is characterized by leaves with prominent nerves; pubescent scape and pedicels while the genus *Ledebouria* in contrast has leaves lacking prominent nerves and glabrous scape and pedicels.

Jessop (1970), considering only the South African taxa and including both leaf and floral characteristics (Table 1), indicated that the two genera are clearly distinguished and suggested that they are not even closely related.

Table 1: Comparison of Significant Morphological Features of *Scilla* and *Ledebouria*

Ledebouria	*Scilla*
Leaves often conspicuously spotted	Leaves uniform green
Inflorescence usually axillary	Inflorescence terminal
Inflorescence usually flexuose and softer	Inflorescence erect and rigid
Perianth segments often pink or white strongly marked with green	Perianth segments blue or rarely pink or white
Filaments free from one another	Filaments united towards the base
Ovary conical, expanding to a wide base below which it constricts very abruptly to the distinct pedicel	Ovary oblong
Ovules basal, two in each locule	Ovules axile, several (rarely 2) per each locule
Testa cells rectangular, arranged in rows	Testa cells polygonal

Source: Jessop (1970 and 1975)

Commenting on the distinctions of the two genera based on the South African materials, Stedje (1998) indicated that the morphological distinction between *Ledebouria* and *Scilla* becomes less clear when materials from tropical Africa and Mediterranean are included. At present, only the S*cilla* species from Europe, Southeast Asia and the Mediterranean region are considered to represent true *Scilla* (Pfosser and Speta, 1999). For the *Scilla* species in sub-Saharan Africa there is a reduction in the number of ovules per locules. This feature is the diagnostic feature to distinguish the genera *Drimiopsis* and *Ledebouria* from the other genera in the family. For species of *Scilla* known from the sub-Saharan Africa, approximately half of them had 1-2 ovules per locule (Marie 1958, cited in Stedje, 1998). Stedje (1998) commented that, although the morphological differences between *Scilla* and *Ledebouria* are not very clear as such, she was able to observe some differences in the DNA sequences of the two taxa and then suggested that they should be treated as separate genera. The DNA sequence analysis done by Pfosser and Speta (1999) and Manning *et al*., (2004) also supports the work of Stedje (1998). Even if a need for requirement of further study is there, currently the two genera are treated separately.

Another genus that is often confused with the genera *Ledebouria* and *Drimiopsis*, due to its superficial resemblance, is *Resonova* Van. (Hankey, 2003). The genus *Resnova* was considered as a synonym of *Drimiopsis* by Jessop (1972). Although the genus *Resnova* has been reinstated in publication (Muller-Dobllies and Muller-Dobllies, 1997), it is still remained as a synonym in current literatures, the reason given being due to technicalities concerning certain type specimens (Hankey, 2003). However, *Resnova* can easily be distinguished from *Ledebouria* and *Drimiopsis* based on its floral characteristics. Unlike

the two genera; it has a biseriate stamens; unlike *Ledebouria*, it has a sessile ovary and unlike *Drimiopsis* it has a campanulate tepals (Hankey, 2003).

Even though *Drimiopsis* and *Ledebouria* can easily be identified from each other based on morphological features, they form a monophyletic group, which has diverged considerably from the genus *Scilla* (Stedje, 1998). Stedje (1998) made a cladistic analysis of both morphological and DNA sequence data of species from tropical Africa, the Mediterranean and India. She considered two chloroplast DNA regions; the intergenic spacer between the transfer RNA genes L (UAA) and F (UAA) and L (UAA) intron.

The DNA sequence divergence between the two genera, genera *Ledebouria* and *Drimiopsis*, was found to be 1.4 to 4% for the intron and 1.7-4.8% for the spacer region, a divergence comparable to that is found within *Ledebouria* species. This is particularly so within the species complex *L. revoluta*, which appears to be a paraphyletic group with a relatively high in-group divergence of the DNA sequence studied. Similarly, the taxon is highly variable regarding karyotype and morphology (Jessop, 1972; Stedje, 1996b) and might contain some more species. So, further studies on morphology, chromosome cytology and crossing experiments throughout its total distribution of the species is required.

Manning *et al*., (2004), in their revised generic synopsis of Hyacinthaceae in sub-Saharan Africa, based on molecular evidence, indicated that *Drimiosis*, *Ledebouria* and *Resnova* are included in the same clade. The clade containing these genera was not further resolved and provided no support for recognizing more than a single genus. For

these reason, Manning *et al*., (2004) claimed that *Ledebouria* should include both of the genera and should be circumscribed by globose or top-shaped ovary containing two ovules per locule. In addition, most species belonging to the above three genera have spotted leaves, produce more than a single inflorescence per plant in one growing season and their bulb scales are often loosely packed and produce fine threads when torn (Manning *et al*., 2004).

Even though the third genus *Resnova* was not included, Pfosser and Speta (1999) supported the close relationship between *Ledebouria* and *Drimiopsis*; after sequencing the trnL-trnF intergenic spacer region of chloroplast DNA for 105 taxa in Hyacithaceae and 18 species of related families.

1. 4. Chromosome Cytology

In addition to morphological features, cytotaxonomical features may also have a great role in indicating the phylogenetic relationships of the aforementioned taxa and in the generic delimitation between the genera *Ledebouria* and *Drimiopsis*.

With regard to the chromosome cytology of the taxa, *L. revoluta* from Kenya; *L. somaliensis* and *L. urceolata* from Ethiopia are reported to have chromosome numbers 2n = 28, 2n = 30 and 2n = 20, respectively (Stedje, 1996b). For *L. revoluta*, from South Africa, a series of haploid chromosome numbers, n = 9, 10, 11, 12, 13, 15, 16 and 22 have been reported (Jessop, 1972). Similarly, variation in chromosome number within other species of the genus is commonly reported. The list of chromosome numbers published for species of *Ledebouria* from Africa, south of the Sahara, and India are presented in Tables 2 and 3, respectively.

The Ethiopian endemic, *L. urceolata*, is morphologically closely related to *L. revoluta* (Stedje and Thulin, 1995). However, the karyotypes of the two species are very different according to Stedje (1996b).

Table 2: Chromosome Counts Reported for Different Species of *Ledebouria* from Different Parts of Africa.

Species	Cited as	Chromosome no	Locality	Reference
L. apartifolia (Bak.) Jess.	*Scilla linearifolia*	2n = 24	Mozambique Matola	Fernandes and Nerves (1962); cited in Natarajan (1994)
Ledebouria concolor (Bak.) Jess.	*Ledebouria concolor*	n = 18	S. A.: Cape	Jessop (1972)
Ledebouria cooperi (Bak.) Jess.	*Ledebouria cooperi*	n = 10	S. A.: Transvaal	Jessop (1972)
L. cooperi	*Ledebouria cooperi*	n = 13	S. A.: Natal	Jessop (1972)
L. cooperi	*Ledebouria cooperi*	n=15	S. A.: Natal	Jessop (1972)
Ledebouria floribunda (Bak.) Jess.	*Ledebouria floribunda*	n = 10	S. A.: Cape	Jessop (1972)
L. floribunda	*Ledebouria floribunda*	n = 11	S. A.: Natal	Jessop (1972)
L. floribunda	*Ledebouria floribunda*	n = 17	S. A.: Cape	Jessop (1972)
L. floribunda	*Ledebouria floribunda*	n = 30	S. A.: Natal	Jessop (1972)
Ledebouria graminofolia (Bak.) Jess.	*Scilla stenophylla*	n =1 2	Unknown, probably Africa, south of Sahara	Gimmenez-Martin (1959); cited in Natarajan (1994)
L. hyacinthina Roth	*Scilla hyacinthina*	2n = 26	Origin S.A.: cultivated in RBG, Edinburgh	Ratter and Milne (1973); cited in Natarajan (1994)

Ledebouria luteola Jess	*Ledebouria luteola*	n = 46	S. A.: Transvaal	Jessop (1972)
Ledebouria marginata (Bak.) Jess.	*Ledeburia marginata*	n = 13	S.A.: Cape	Jessop (1972)
Ledebouria ovatifolia (Bak.) Jess.	*Ledebouria ovatifolia*	n = 27	S. A.: Natal	Jessop (1972)
L. revoluta (L. f.) Jess	*Ledebouria revoluta*	n = 10, 13, 15, 16	S.A.: Cape	Jessop (1972)
L. revoluta	*Ledebouria revoluta*	n = 10, 12	S. A.: Natal	Jessop (1972)
L. revoluta	*Ledebouria revoiluta*	n = 11, 12	S. A.; Transvaal	Jessop (1972)
L. revoluta	*Ledebouria revoluta*	n = 17	S. A.: Swaziland	Jessop (1972)
L.revoluta	*Ledebouria revoluta*	n = 9, 10	S. A.; Rhodes University Garden	Jessop (1972)
L.revoluta	*Ledebouria revoluta*	2n = 28	Kenya	Stedje (1996b)
L. somaliensis	*Ledebouria somaliensis*	2n = 30	Ethiopia	Stedje (1996b)
L. ureceolata	*Ledebouria urceolata*	2n = 20	Ethiopia	Stedje (1996b)
Ledebouria species	*Scilla cameroniana*	2n = 46	Unknown, probably Africa south of Sahara	Gimenez Martin (1959); cited in Natarajan (1994)
Ledebouria scabrda Jess.	*Ledebouria scarbida*	2n = 40	S. A.: Nambia	Jessop (1972)
Ledebouria socials (Bak.) Jess	*Ledebouria socials*	n = 13, 15	S. A.: Cape	Jessop (1972)
Ledebouria undualata (Jacq.) Jess.	*Ledebouria undulata*	n = 10, 13, 14, 15, 20-30	S. A.: Cape	Jessop (1972)

Table 3: Chromosome Counts Reported from India for *L. hyacinthina*

Species	Cited as	Chromosome number	Locality	Reference
L. hyacinthina *Roth*	*Scilla indica*	2n = 44, 45, 46	Madras	Raghavan and Venkatasubban (1939)
L. hyacinthina	*Scilla indica*	2n = 30	Kolar hills, Mysore state	Sheriff and Murthy (1946)
L. hyacinthina	*Scilla indica*	2n = 58	Sauger	Rao (1953)
L. hyacinthina	*Scilla indica*	2n = 30	Bombay, Dharwar, Mysore and Tiruchinnapalli	Rao (1956)
L. hyacinthina	*Scilla indica*	2n = 45, 46	Madras	Rao (1956)
L. hyacinthina	*Scilla indica*	2n = 58, 60	Sagar	Roa 1956
L. hyacinthina	*Scilla indica*	2n = 60	Nagpur	Rao (1956)
L. hyacinthina	*Scilla indica*	2n = 30	Bangalore	Sen (1973)
L. hyacinthina	*Scilla indica* 2n= 30 (k)	2n = 30	Poona, Kolhapur, Ramdurg, Londa, Hyderabad, Dhrawar D. J., kolar	Sheriff (1979)
L. hyacinthina	*Scilla indica*	n = 10	Maharasha, Uklapani	Sarkar et al., (1980)
L. hyacinthina	*Scilla indica*	2n = 20, 22, 44, 45, 46		Subramanian (1981)
L. hyacinthina	*Scilla indica*	2n = 45	Madras	Shriff and Rao (1981)

Source: Natarajan (1994)

A collection of *D. barteri* from different parts of Nigeria was reported to have a somatic chromosome number of 2n = 24 (Oyewole, 1984a). These chromosomes fall into 12 morphological pairs with members of the pair generally unequal. Oyewole (1984b) also reported 3-10 μm ranges in chromosome length and revealed that seven of the pairs are longer than 5 μm; four pairs have terminal to sub terminal centeromeres while the others have sub median to median centromeres. Darlington and Wylie (1955) reported a basic chromosome number x = 8 for the genus from South African materials which indicates the somatic chromosome number 2n = 24 is triploid.

However, Oyewole (1984a) showed that the basic number of x =6 rather than x =8 is more consistent with the somatic complement of the West African species of *Drimiopsis*. But, Stedje (1994) claimed that the basic chromosome number for West African *Drimiopsis* species is 12. In her revision of the genus *Drimiopsis* in sub-Saharan Africa, Stedje (1994) also indicated the basic chromosome for the taxon is 10 and 11 for south African and east African species of the taxon, respectively. But, Lebatha *et al*., (2003) supported Darlington and Wylie (1955) i.e. the West African species of the genus have x = 8. They also supported the basic chromosome numbers claimed by Stedje (1994) for south and east African species.

Table 4: Chromosome Numbers of *Drimiopsis*

Region	Taxon	n	2n
Tropical Africa	*D. barteri* Baker		20, 44,
	D. botryoides ssp *botryoides* Bak.		44, 55, 66, 80
	D. botryoides ssp *prostrata* Stedje		22
	D. kirkii Baker	16, 22, 30, 32, 33, 34	60, 66, 68
	D. volkensii (Engl.) Baker		64
Southern Africa	*D. burkei* ssp *burkei* Bak.		44
	D. burkei ssp *stolonissima* U. Muller-Doblies		40
	D. burkei ssp *crenata* Van der Merwe		20
	D. burkei ssp *maculata* Lindl. and paxt.	15	60
	D. maxima Baker		20
	D. pusilla U. Muller-Doblies		44
	D. saundersiae Baker		20

Adopted from Lebatha *et al*., (2003)

Stedje and Nordal (1987) carried out cytological studies of Hyacinthaceae in sub-Saharan Africa and reported that all the *Drimiopsis* species they considered from East Africa have chromosome numbers with four ploidy levels; di, tetra, penta and hexaploidy. According to them, *D. botryoides* ssp *botryoides* from the region have chromosome numbers 2n = 44, 55 and 66 which indicate tetra, penta and hexaploidy, respectively. Stedje (1994) also reported that *D. botryoides* spp *prostrata* from the region has 2n=22 which increased the polidy levels of the genus into four.

Gill (1978) reported a chromosome number 2n = 64 for *D. botryoides* ssp *botryoides* from Tanzania which doesn't go with the ploidy levels reported for East African taxa. Rather, it supports the basic chromosome number x =8 reported for West African species of the genus.

Generally, it is possible to say that the plants belonging to the two genera, *Ledebouria* and *Drimiopsis*, have evolved different cytotaxonomical features and show high variation within a genus and species showing no trend or little trend in ploidy level series (Tables 2, 3 and 4). With regard to the chromosome cytological studies of Ethiopian taxa, little studies have been done. For some of the taxa, chromosome numbers have not been reported yet. Because of the great variation in chromosome number within a species, even the probability of reporting a new chromosome number for the taxon whose chromosome number has been already documented is also there.

The chromosome numbers published for *Drimiopsis* to date represent only one-third of the genus (Lebatha *et al*., 2003). No chromosome number is reported for the genus from Ethiopia. Although molecular methods have become more and more popular and easy in studies on systematics and evolution of plants, it is often necessary to know the chromosome number and karyotypes of a given taxon. Moreover, chromosome number, karyotype and morphological studies serve as base line information for the molecular studies.

Taking all these and other present existing knowledge gap with regard to the description of the taxa and generic delimitation between the two genera, the present study attempts to achieve the following objectives.

2. OBJECTIVES

2.1 General objective: To re-visit the taxonomy and chromosome cytology of the genera *Ledebouria* and *Drimiopsis* (Hyacinthaceae) in Ethiopia so as to expand the species description and improve their classification.

2.2 Specific objectives:

- To see the generic delimitation between the two genera based on the Ethiopian species of the taxa ;
- To collect additional information on both vegetative and floral characteristic features;
- To document chromosome numbers of the taxa; and
- To describe the karyotypes of the taxa

3. MATERIALS AND METHODS

3.1 Plant materials used in the study

Some of the plant taxa belonging to the genera *Ledebouria* and *Drimiopsis* were collected from different parts of the country. Sample specimen of the plant species were taken from their natural localities and transplanted to pots in the green house at Science Faculty, Addis Ababa University. Then fresh root tips from individual specimen were used in somatic chromosome analysis. Morphological taxonomic information was generated from the specimens selected from the National Herbarium of Addis Ababa University (ETH) and from the specimens grown in the green house.

3.2 Somatic chromosome analysis

For somatic chromosome studies, actively growing root tips (3-4 cm) were harvested from the specimens that were grown in the greenhouse. The root tips were treated with colchicines (0.05%) for about 6 hours at room temperature. The root tips were then transferred into clean vials and fixed in ethanol: acetic acid (3:1) overnight following Stedje (1996b). After rinsing in several changes of distilled water, enzyme maceration was performed in 4% cellulase + 4% pectinase solution for about 1 hour at 35-37°C follwing Kifle Dagne and Heneen (1992). These root tips were rinsed in distilled water after decanting the enzyme solution.

3.2.1. Slide preparation

The enzyme macerated root tips were pipetted on to a glass slide. The excess water was blotted off using absorbant paper and the root tips were mashed in a drop of fresh fixative and spread by strongly bellowing on the slide. These slides were made air dry at room temperature (Kifle Dagne and Heneen, 1992).

The air-dry slides were stained with drops of aceto-orecin under cover slip and excess stain was removed by pressing the cover slip with absorbant paper. Slides with better chromosome preparations were made semi permanent by sealing around the edge of the cover slip. Permanent slide preparations were also made by staining air dry preparation in Giemsa stain in Sorensen's phosphate buffer (pH = 6.8) followed by rinsing in the same buffer, air drying and mounting in Dpx.

These slides were analyzed under a light microscope and photographs were taken from both the preparations. Numbering and karyotyping were made on the photomicrographs of the somatic chromosomes. The nomenclatures used in defining the centeromeric position (m, sm, st and t) were adopted from Levan *et, al*. (1964). Chromosome size and arm ratio measurements were made on enlarged photomicrographs. The measurements were made using computer application micromeasure software version 3:2 (available via the Internet at http://www. Colostate. edu/Depts/Biology/Micromeasure).

3.3. Morphological phenotypic characteristics

The specimens that were used for morphological studies were obtained from those deposited at the National Herbarium (ETH) and specimens that were collected from different parts of the country and grown in the glasshouse at Faculty of Science, Addis Ababa University.

For quantitative morphological data that requires measurement, a hand ruler was used for both vegetative and reproductive parts. Dry floral parts were also boiled in water for few minutes or soaked in ethanol for several hours to get them softened and a binocular microscope was used to assist in observing plant parts whenever necessary.

Arithmetic mean and standard deviations from the mean were calculated for the total number of specimens examined in every taxon (n). Variation in morphological characteristics among each taxon were presented in the form of histogram. One way ANOVA was also computed to see the variation among different species with regard to the generated morphological characteristic features using a computer application software SPSS version 11. NTSYS version 2:1 was used to construct dendrograms. The qualitative and quantitative features used are shown in Table 5.

Table 5: List of Qualitative and Quantitative Morphological Features Examined per Each Specimen

Quantitative morphological features	Qualitative morphological features
Plant height (PHT)	
Leaf number (LFN)	
Leaf length (LFL)	Leaf shape (LFS)
Leaf width (LFW)	Leaf base (LFB)
Lefa length to width ration (LLWR)	Leaf margin (LFM)
Petiole length (PTL)	Leaf apex (LFA)
Pseudopetiole length (SPTL)	Leaf spot color (LFSP)
Peduncle number (PDN)	Leaf color (LFC)
Peduncle length (PDL)	Leaf dimorphism (LFD)
Inlforescence length (IFL)	Petiole ± (PPA)
Number of flowers per inflorescence (NOF)	Bract presence-absence (BRPA)
Number flowers per 2 cm inflorescence length (NOFT)	Inflorescence type (IFT)
Pedicel length (PDCL)	Perianth color (PRC)
Perianth length (PRL)	Perianth dimorphism (PDM)
Perianth width (PRW)	Filament morphology (FLM)
Perianth elngth to width ratio (PLWR)	Ovary stalk ± (OSPA)
Stamen length (STL)	
Pistil length (PSL)	

4: RESULTS

A sufficient number of specimens were used for the study (Appendix 1 and 2). However, many specimens were incomplete, thus making it impossible to have measurements for every feature as initially planned. It was thus inevitable that morphological data have been presented with some missing source of data like fruit and seed features, perianth color and leaf spot color. Even though *L. edulis* is mentioned in the Flora, no herbarium collection of it could be obtained and as a result it is not included in the result and discussion.

From the generated morphological features, it was generally observed that values for the various measurements displayed extensive overlap in their ranges. For *Ledebouria* species, these values have been summarized and presented in Table 6 for the quantitative morphological data and in Table 7 for the qualitative morphological data. Similarly, the summary of quantitative and qualitative morphological data generated for *Drimiopsis* species are also presented in Table 8 and 9, respectively. Detailed morphological data have been presented in Appendcies 1 and 2 for *Ledebouria* species and *Drimiopsis* species, respectively.

Table 6: Summery of Quantitative Data of the Species under the Genus *Ledebouria*

Species	***L. somaliensis***		***L. kirkii***		***L. cordifolia***		***L. revoluta***		***L. urceolata***	
	Range	**Mean ± SD**	**Range**	**Mean ± SD**	**Range**	**Mean ± SD**		**Mean ± SD**	**Range**	**Mean ± SD**
Plant height (cm)	25-42	34.0 ± 2.7	28-40	32.0 ± 4.0.	15-25	21.1 ± 2.1	17-29	22.9 ± 1.0	9-17	13.4 ± 1.5
Leaf number	4-6	5.2 ± 0.3	1-2	3.0 ± 1.5	1-2	1.5 ± 0.2	2-7	3.5 ± 0.3	2-4	3 ± 0.3
Leaf length (cm)	8-13.5	11.1 ± 0.8	15-16	15.6 ± 0.3	6.5-13	9.0 ± 0.7	4-16	10.3 ± 0.8	1-16	8.4 ± 2.5
Leaf width (cm)	3.9-6.2	4.6 ± 0.3	3.5-4	3.7 ± 0.2	4-8.5	6.2 ± 0.5	1.2-4	2.5 ± 0.2	1-2.7	1.8 ± 0.3
Leaf length/width ratio	1.6-3.5	2.4 ± 0.3	3.8-4.6	4.3 ± 0.3	1-2.2	1.5 ± 0.13	1.9-10	4.7 ± 0.6	1-7.3	4.2 ± 1.0
Petiole length (cm)					3-4	4.8 ± 0.9				
Pseudopetiole length (cm)	1-3	1.9 ± 0.3	5-6	5.5 ± 0.3	1.5	2.1 ± 0.6	1-6	3.6 ± 0.4	3-6.3	3.56 ± 0.94
Peduncle number	1-5	15.8 ± 1.4	1-2	17.3± 1.9	1-3	13.5± 1.9	1-3	11.0± 0.9	1-3	9.2 ± 3.6
Peduncle length (cm)	10-19	2.7± 0.6	15-21	1.5± 0.5	9-18	1.5 ± 0.5	7-17	1.8± 0.16	4-23	2 ± 0.3
Raceme length (cm)	9.3-20	14.2 ± 1.6	6-17	11.2 ± 3.2	5-8.5	6.8 ± 0.8	3.6-14	7.9 ± 0.8	3-9	5.6 ± 1.1
No of flowers per inflorescence	45-75	61.2 ± 4.3	27-54	37.7± 8.3	35-50	40.5± 3.4	23-81	44.5 ± 4.6	22-38	31.8 ± 3.1
Number flowers/2 cm inflorescence length	10-18	13.7 ± 1.1	8-10	9.0± 0.6	12-16	14.3 ± 0.9	11-21	15.2 ± 0.9	13-18	15.0 ± 0.95
Pedicel length (cm)	0.2-0.4	0.3± 0.03	0.6-1.8	1.3 ± 0.35	0.5-0.7	0.65 ± 0.05	0.3-0.7	0.5 ± 0.04	0.4-0.7	0.5 ± 0.0
Perianth length (cm)	0.9-1.1	0.2 ± 0.02	0.9-1.1	0.16 ± 0.01	0.5-0.7	0.17 ± 0.02	0.3-0.7	0.14 ± 0.01	0.5	0.2 ± 0.0
Perianth width (cm)	0.12-0.2	0.97 ± 0.03	0.14-0.18	0.97 ± 0.07	0.12-0.2	0.63± 0.05	0.1-0.2	0.48 ± 0.03	0.19-0.2	0.5 ± 0.0
Perianth length/width ratio	5-12.5	7.1 ± 1.2	5.3-6.4	6.0 ± 0.3	2.9-5.8	3.8 ± 0.7	1.88-7	3.6 ± 0.3	2.5-4.6	2.5 ± 0.0
Stamen length (cm)	0.7-1.1	0.93 ± 0.06	0.4-1.1	0.7 ± 0.2	0.4-0.5	0.45± 0.03	0.27-0.7	0.4± 0.03	0.5	0.5 ± 0.0
Pistil length (cm)	0.6-1.1	0.8 ± 0.07	0.4-1.1	0.7 ± 0.2	0.4-0.5	0.43 ± 0.03	0.2-0.7		0.3 ± 0.03	

Table 7 Qualitative Characteristic Features of *Ledebouria* species

Species	Specimen	Leaf Shape	Leaf base	Leaf margin	Leaf apex	Leaf spot	Inflorescence Type	Perianth color
L. somaliensis	Ensermu, Goweller, Lamessa 3022	Broadly lanceolate	Cuneate	Entire	Acute	Dark mottles	Raceme	Green
	Ensermu, Goweller, Lamessa 3108	Broadly lanceolate	Cuneate	Entire	Acute	Dark bloches	Raceme	Greenish yellow
	Ensermu, Goweller, Lamessa 3084	Broadly lanceolate	Cuneate	Entire	Acute	Purple	Raceme	Green
	T. Haugen 1775	Broadly lanceolate	Cuneate	Entire	Acute		Raceme	Purple
	Friis, Mesfin Tadessa, K. Vollesen 2763	Broadly lanceolate	Cuneate	Entire	Acute	Violet	Raceme	Green
	Friis, M. G. Gilbert, F. Rasmessen 1023	Broadly lanceolate	Cuneate	Entire	Acute		Raceme	
L. kirkii	Schleoder, Jacobs, 690	Lanceolate	Cuneate	Entire	Acute		Raceme	Purple
	T. Haugen 1784,	Lanceolate	Cuneate	Entire	Acute		Raceme	
	Schloeer and Jacobs 659	Broadly lanceolate	Cuneate	Entire	Acute	Purple	Raceme	Purple
L. cordifolia	Chaffi 437	Cordate	Cordate	Entire	Mucronate		Raceme	
	Nordal, Melaku and Petros 2278	Cordate	Cordate	Entire	Mucronate	Purple	Raceme	Purple
	Desalegn Chala 15	Cordate	Cordate	Entire	Mucronate		Raceme	
	Desalegn Chala 18	Cordate	Cordate	Entire	Mucronate		Raceme	
	Desalegn Chala 19	Cordate	Cordate	Entire	Mucronate			
	Desalegn Chala 10	Cordate	Cordate	Entire	Mucronate			
	Desalegn Chala 11	Cordate	Cordate	Entire	Mucronate			
	Desalegn Chala 13	Cordate	Cordate	entire	mucronate			
	Desalegn Chala 14	Cordate	Cordate	Entire	Mucronate			
	Desalegn Chala 17	Cordate	Cordate	Entire	Mucronate			

L. revoluta	Jerry 1013	Narrowly lanceolate	Cuneate	Entire	Acute		Raceme	
	Mooney 8903	Narrowly lanceolate	Cuneate	Entire	Acute		Raceme	
	Mooney 8903	Narrowly lanceolate	Cuneate	Entire	Acute		Raceme	
	Mooney 8944	Narrowly lanceolate	Cuneate	Entire	Acute		Raceme	
	C. Herman 137	Narrowly lanceolate	Cuneate	Entire	Acute		Raceme	
	M. G. Gilbert and B. M. G. Jones 107	Narrowly lanceolate	Cuneate	Entire	Acute		Raceme	
	O. Ryding and Ermias K. 1001	Narrowly lanceolate	Cuneate	Entire	Acute		Raceme	
	M. G. Gilbert and B. M. G. Jones 103	Narrowly lanceolate	Cuneate	Entire	Acute		Raceme	
	T. Haugen	Lanceolate	Cuneate	Entire	Acute		Raceme	
	M.G. Gilbert and M. B. Jones 28	Narrowly lanceolate	Cuneate	Entire	Acute		Raceme	
	Ensermu Kelbessa and Melaku wendafrash 2965	Narrowly lanceolate	Cuneate	Entire	Acute		Raceme	
	C. Herman 224	Narrowly lanceolate	Cuneate	Entire	Acute		Raceme	
	Desalegn Chala 21	Broadly lanceolate	Cuneate	Entire	Acute		Raceme	
	Melaku, Powys, Diolli, Samuel 408	Broadly lanceolate	Cuneate	Entire	Acute		Raceme	
	Desalegn Chala 27	Broadly lanceolate	Cuneate	Entire	Acute		Raceme	
	Desalegn Chala 30	Broadly lanceolate	Cuneate	Entire	Acute		Raceme	
	Tesfaye Awas 1155	Narrowly lanceolate	Cuneate	Entire	Acute		Raceme	Purple
	Desalegn Chala 22	Elliptic	Cuneate	Entire	Acute		Raceme	Purple
L.*urceolata*	Sebsebe 33a	Narrowly lanceolate	Cuneate	Entire	Acute		Raceme	Purple
	Getachew 2973	Lanceolate	Cuneate	Entire	Acute		Raceme	Purple
	Christoff 141	Narrowly lanceolate	Cuneate	Entire	Acute		Raceme	Purple
	Sebsebe D., Nigist A., and A. Hunde 388	Narrowly lanceolate	Cuneate	Entire	Acute		Raceme	Purple
	M. Thulin and A. Hunde 3916	Narrowly lanceolate	Cuneate	Entire	Acute	Violet	Raceme	Purple

4.1 Computations of quantitative morophological results of *Ledebouria*

4.1.1 Plant height

Ledebouria somaliensis was the higher scorer (34 ± 2.7 cm) with respect to plant height, while *L. urceolata* was the least (13.4 ± 1.5 cm). The average plant height was 24 ± 1.3 cm for the genus *Ledebouria*. The least observed variability was 1 cm (*L. revoluta*) while the largest was 4 cm (*L. kirkii*). The average (mean ± SD) plant height for all species of *Ledebouria* is presented in Figure 1. Test of homogeneity at $P < 0.05$ witnessed that group variance were homogeneous ($P = 0.236$) (Appendix 3). One way ANOVA showed that *L. somliensis* and *L. kirkii* are closely related to one another and significantly different from others at $P < 0.05$ with respect to plant height. The computed one way analysis of variance also shows a significant variation between *L. revoluta* and *L. urceolata*.

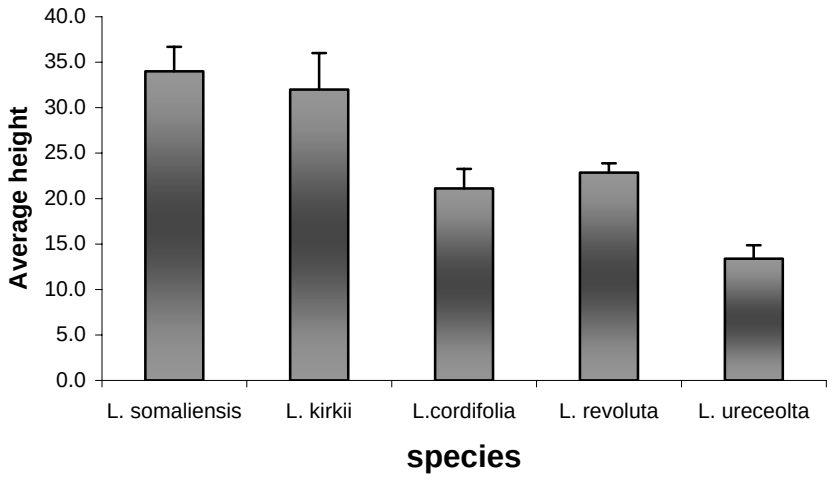


Figure 1. Mean height (mean ± SD in cm) of *Ledebouria* species

4.1.2 Leaf Characteristics

Test of homogeneity at $P < 0.05$ witnessed that the group variances were not homogenous with respect to leaf number ($P = 0.00$) and leaf length to width ratio ($P = 0.03$). But, the variances were homogenous for leaf length ($P = 0.236$) and leaf width ($P = 0.056$).

4.1.2.1 Leaf number

Leaf number for *L. somaliensis, L. kirkii, L. cordifolia, L. revoluta* and *L. urceolata* ranged from 4-6, 1-2, 1-2, 2-7, and 2-4 cm, respectively. *L. somaliensis* had the highest average leaf number (5 $\pm$ 0.3) while *L. cordifolia* had the least (2 $\pm$ 0.2). The average leaf number for the genus *Ledebouria* is 3 $\pm$ 0.2 and it ranged from 1-7. The computed one way ANOVA showed a significant difference of *L. somaliensis* from all others except from *L. kirki* (P = 0.967). The significant difference was also observed between *L. cordifolia* and *L. revoluta* (P = 0.000). One way ANOVA also indicated that *L. kirkii* and *L. urceolata* are related to each other and to other *Ledebouria* species.

4.1.2.2 Leaf length

The leaf length measured for *L. somaliensis, L. kirkii, L. cordifolia, L. revoluta* and *L. urceolata* ranges from 8-13.5, 15-16, 6.5-13, 4-16 and 1-16 cm, respectively. The highest average leaf length was measured for *L. kirkii* (15.7 $\pm$ 0.3 cm) while *L. urceolata* had the least (8.4 $\pm$ 2.5 cm). The average leaf length measured for the genus was 10.2 $\pm$ 0.5 cm. The least variability was observed for *L. kirkii* (0.3 cm) while the highest was for *L. uroceolata* (2.5 cm).

The computed one way ANOVA indicated a significant difference of *L. kirkii* from *L. cordifolia* (P = 0.024) and *L. urceolata* (P = 0.027).

4.1.2.3 Leaf width

Leaf width ranges of 3.9-6.2, 3.5-4, 4-8.5, 1.2-4 and 1-2.7 cm were measured for *L. somaliensis, L. kirkii, L. cordifolia, L. revoluta* and *L. urceolata*, respectively. The highest leaf width was measured for *L. cordifolia* (6.2 $\pm$ 0.5 cm) while the least was for *L. urceolata* (1.8 $\pm$ 0.3 cm). The average leaf width for the genus is 3.7 $\pm$ 0.3 cm. The least variability was observed was for *L. kirkii* and *L. revoluta* (0.2) while the highest was for *L. cordifolia* (0.5). The computed one way ANOVA clearly indicated that: *L. somliensis* was significantly different from all others except from *L. kirki* (P = 0.725); a significant difference between *L. kirkii* and *L. cordifolia* (P = 0.007) and between *L. cordifolia* and *L. revoluta* (P = 0.000).

4.1. 2. 4 Leaf length to width ratio

The ranges of leaf length to width ratio calculated for *L. somaliewnsis*, *L. kirkii*, *L. cordifolia*, *L. revoluta* and *L. urceolata* were 1.6-3.5, 3.8-4.6, 1-2.2, 1.9-10 and 1-7.3, respectively. *L. revoluta* had the highest leaf length to width ratio (4.71 $\pm$ 0.59) while *L. cordifolia* had the least (1.52 $\pm$ 0.13). Multiple comparison of one way ANOVA showed a significant differences between; *L. somaliensis* and *L. cordifolia* (P = 0.031), *L kirkii* and *L. cordifolia* (P = 0.022) and *L. cordifolia* and *L. revoluta* (P = 0.001).

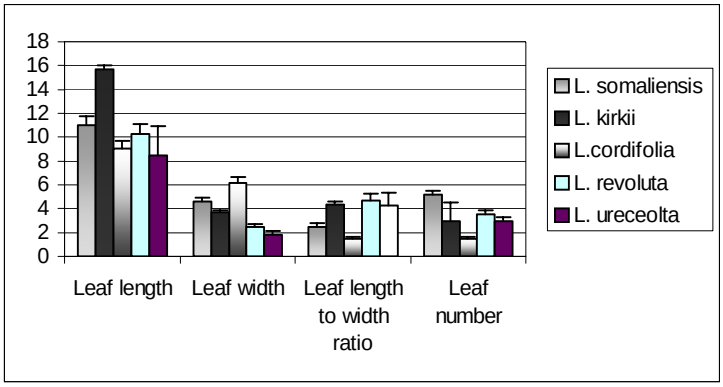


Figure 2. Mean leaf characteristic features (mean ± SD in cm) of *Ledebouria* species

4.1. 3 Floral Characteristic Features

Test of homogeneity at $P < 0.05$ witnessed that the group variances were not homogenous with respect to pedicel length ($P = 0.000$), perianth width ($P = 0.002$), perianth length ($P = 0.001$), stamen length ($P = 0.001$) and pistil length ($P=0.002$). But, the variances were homogenous for peduncle length ($P = 0.356$), raceme length ($P = 0.348$) number of flowers within 2 cm raceme length ($P = 0.248$) and perianth length to width ratio ($P=0.051$).

4.1. 3. 1 Pedicel length

Pedicel length measured ranges from 0.2-0.4, 0.6-1.8, 0.5-0.7, 0.3-0.7, and 0.4-0.7 in cm for *L. somaliensis, L. kirkii, L. cordifolia, L. revoluta* and *L. urceolata,* respectively. The highest average pedicel length was 1.27 $\pm$ 0.35 cm for *L. kirkii* and the lowest was 0.27 $\pm$ 0.03 cm for *L. somaliensis*. The computed multiple analysis of one way ANOVA indicated that *L. kirkii* is significantly different from all other *Ledebouria* species at $P < 0.005$ while others have a significant relation with one another.

4.1.3.2 Peduncle length

The peduncle length measured for *L. somaliensis, L. kirkii, L. cordifolia, L. revoluta* and *L. urceolata* ranges from 10-19, 15-21, 9-18, 7-17 and 4-23 cm, respectively. The highest average peduncle length is 17.33 $\pm$ 1.33 cm (*L. kirkii*) and the lowest is 9.2 $\pm$ 3.56 cm (*L. urceolata*). The average peduncle length for the genus is 12.41 $\pm$ 0.84 cm. The highest variability is observed in *L. urceolata* (0.02 cm) while the lowest is observed in *L. revoluta* (0.93 cm). No species of the genus are significantly different from each other with respect to peduncle length

4.1.3.2 Inflorescence length

Inflorescence length measured for *L. somaliensis, L. kirkii, L. cordifolia, L. revoluta* and *L. urceolata* ranges from 9.3-20, 6-17, 5-8.5, 3.6-14 and 3-9 cm, respectively. The highest average raceme length was 14.2 $\pm$ 1.6 cm (*L. kirkii*) while the lowest is 5.6 $\pm$ 1.1 cm (*L. urceolata*). The highest variability was seen in *L. kirkii* (3.2 cm) while the least

was seen in *L. cordifolia* (0.8 cm). A significant difference was observed between *L. somaliensis* and *L. cordifolia* (P=0.016), *L. somaliensis* and *L. revoluta* (P=0.005) and *L. somaliensis* and *L. urceolta* (P=0.002).

4.1.3.3 Perianth Length

The range of perianth lengths 0.9-1.1, 0.9-1.1, 0.5-0.7, 0.3-0.7, and 0.5 cm were measured for *L. somaliensis*, *L. kirkii*, *L. cordifolia*, *L. revoluta* and *L. urceolata*, respectively. The mean perianth length for the genus is 0.63 $\pm$ 0.04 cm. *L. somaliensis* had the highest average perianth length (0.97 $\pm$ 0.03 cm) while *L.revoluta* had the least (0.48 $\pm$ 0.03 cm). All the taxa under the genus are related with regard to this morphological characteristic feature. But, *L. somaliensis* is significantly different from all others and only related to *L. kirkii* (P = 1.00).

4.1.3.4 Perianth width

The ranges of perianth width 0.12-0.2, 0.14-0.18, 0.12-.2, 0.1-0.2 and 0.19-0.2 cm were measured for *L. somaliensis*, *L. kirkii*, *L. cordifolia*, *L. revoluta* and *L. urceolata*, respectively. The average perianth width measured for the genus was 0.16 $\pm$ 0.01 cm. The highest score was for *L. urceolata* (0.2 $\pm$ 0.00 cm) while the least was for *L. revoluta* (0.14 $\pm$ 0.03 cm). The computed one-way ANOVA is clearly indicated that *L. revoluta* is significantly different from *L. urceolata* (P = 0.000) with regard to perianth width while a significant relation found among others.

4.1.3.5 Perianth length to width ratio

The ranges of the perianth length to width ratio calculated for *L. somaliensis, L. kirki, L. cordifolia, L. revoluta* and *L. urceolata* were 5-12.5, 5.3-6.4, 2.9-5.8, 1.8-7 and 2.5-4.6 cm, respectively. The highest average perianth length to width ratio was obtained for *L. somaliensis* (7.2 $\pm$ 1.1) and the lowest was for *L. urceolata* (2.52 $\pm$ 0.02). *L. kirkii* and *L. revoluta* are the only two species, which is significantly differed (P = 0.989).

4.1.3.5 Stamen length

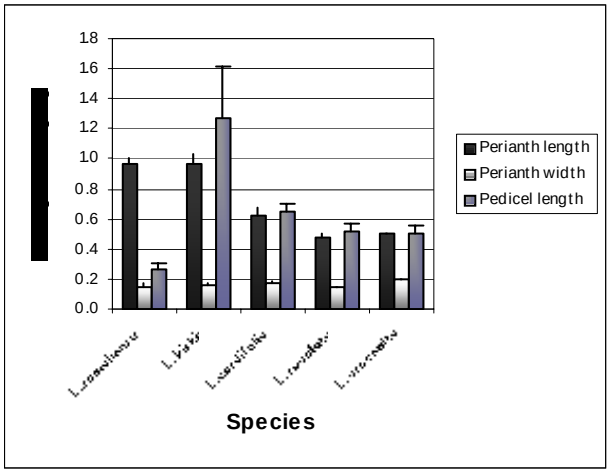
The ranges of stamen length 0.7-1.1, 0.4-1.1, 0.4-0.5, 0.27-0.7 and 0.5 cm were measured for *L. somaliensis, L. kirkii, L. cordifolia, L. revoluta* and *L. urceolata*, respectively. The average stamen length for the genus was 0.56 $\pm$ 0.04 cm. The highest was scored for *L. somaliensis* (0.98 $\pm$ 0.06 cm) and the least was scored for *L.revoluta* (0.44 $\pm$ 0.03 cm). One-way ANOVA also indicated that *L. somaliensis* was significantly different from others while a significant relation is found among others.

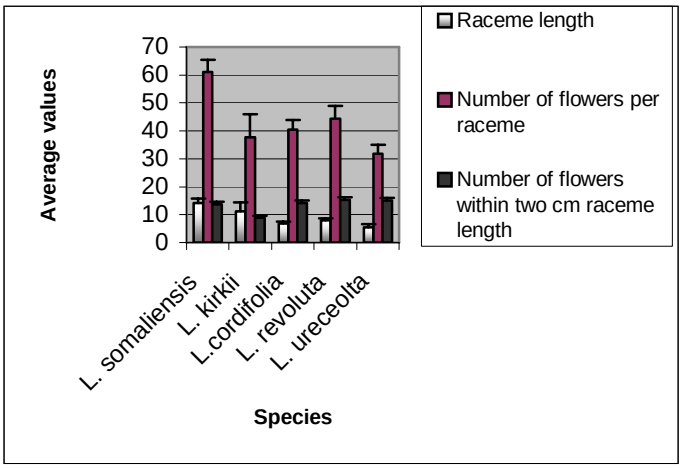
4.3.1.6 Pistil length

The pistil length measured for *L. somaliensis, L. kirkii, L. cordifolia, L. revoluta* and *L. urceolata* ranges between 0.6-1.1, 0.4-1.1, 0.4-0.5, 0.2-0.7, and 0.35-0.5 cm, respectively. The average pistil length for the genus is 0.5 $\pm$ 0.04 cm. The highest average pistil length was measured for *L. somaliensis* (0.83 $\pm$ 0.07 cm) while the least was for *L. revoluta* (0.38 $\pm$ 0.03 cm). The computed one-way ANOVA also indicated that *L. somaliensis* was significantly different from others while a significant relation is found among others.

4.1.3.7. Number of flowers per inflorescence

The number of flowers per raceme ranges from 45-75, 27-54, 35-50, 23-81 and 22-38 for *L. somaliensis*, *L. kirkii*, *L. cordifolia*, *L. revoluta* and *L. urceolata*, respectively. The highest average number of flowers per raceme was 61 $\pm$ 4.3 (*L. somaliensis*) while the lowest was 32 $\pm$ 3 (*L. kirkii*). The highest variability was observed in *L. kirkii* (8.3) while the lowest was in *L. urceolta* (3.1). A significant difference was observed between *L. somaliensis* and *L. urceolta* (P = 0.003).





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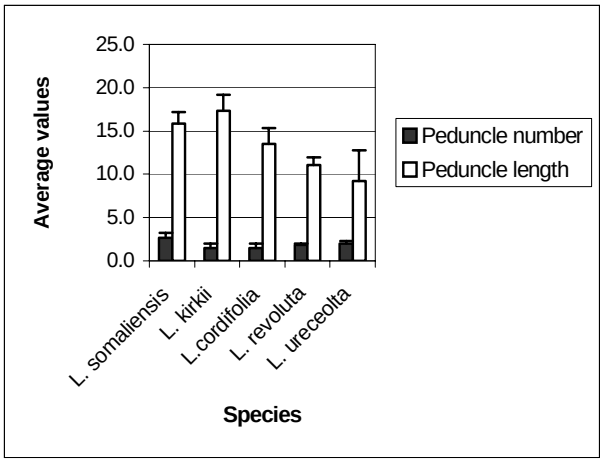

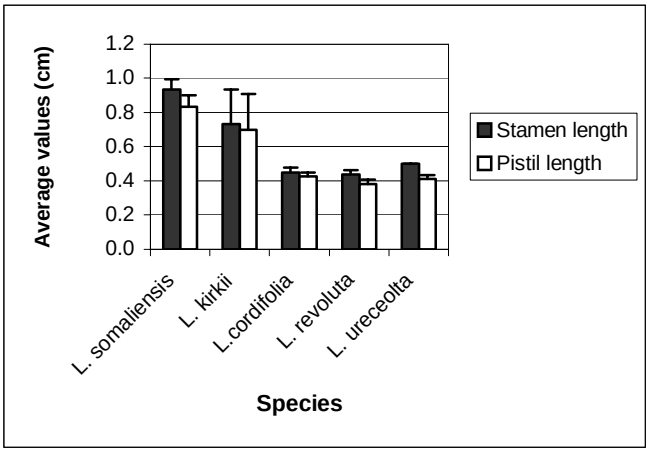

C **D**

Figure 3. Graphs showing the mean ± SD of different floral morphological characteristic features of different *Ledebouria* species.

4.2 Cluster analysis

A cluster analysis was made based on both the qualitative and quantitative morphological data generated for the *Ledebouria* species following hierarchical cluster analysis procedure (NTSYS, version 2:1) (Fig 4).

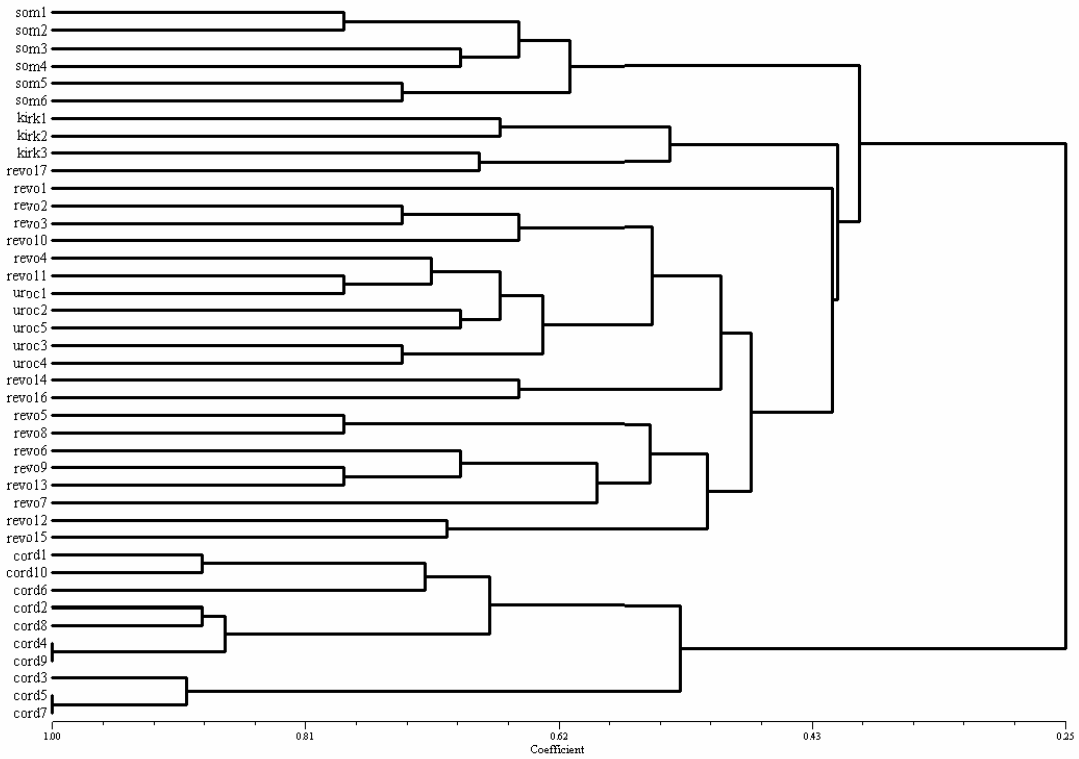

Figure 4. Dendrogram constructed based on the combination of both qualitative and quantitative morphological characteristics of *Ledebouria* (som = *L. somaliensis*, kirk = *L. kirkii*, revo = *L. revoluta*, Uroc = *L. urceolata*, cord = *L. cordifolia*). All the characteristic features on appendix 1 are taken into consideration.

A dendrogram constructed based on these data resulted in grouping of all the specimens studied for the genus *Ledebouria* into five clusters at 0.45 similarity coefficient (Table 8). Pictures that show certain morphological variations among *Ledebouria* species are also presented in Figure 5.

Table 8. The Clusters Generated for *Ledebouria* Species and Specimens Included in Each of the Clusters

Clusters	**Specimens**
Cluster I	som1, som2, som3, som4, som5, som6
Cluster II	kirk1, kirk2, kirk3, revo17
Cluster III	revo1
Cluster IV	revo2, revo3, revo4, revo10, revo4, revo11, uroc1, uroc2, uroc5, uroc3, uroc4, revo14, revo16, revo5 revo8, revo6 revo9, revo13, revo7, revo12, revo15 ,
Cluster V	cord1, cord10, cord6, cord2, cord8, cord4, cord9, cord3, cord5, cord7

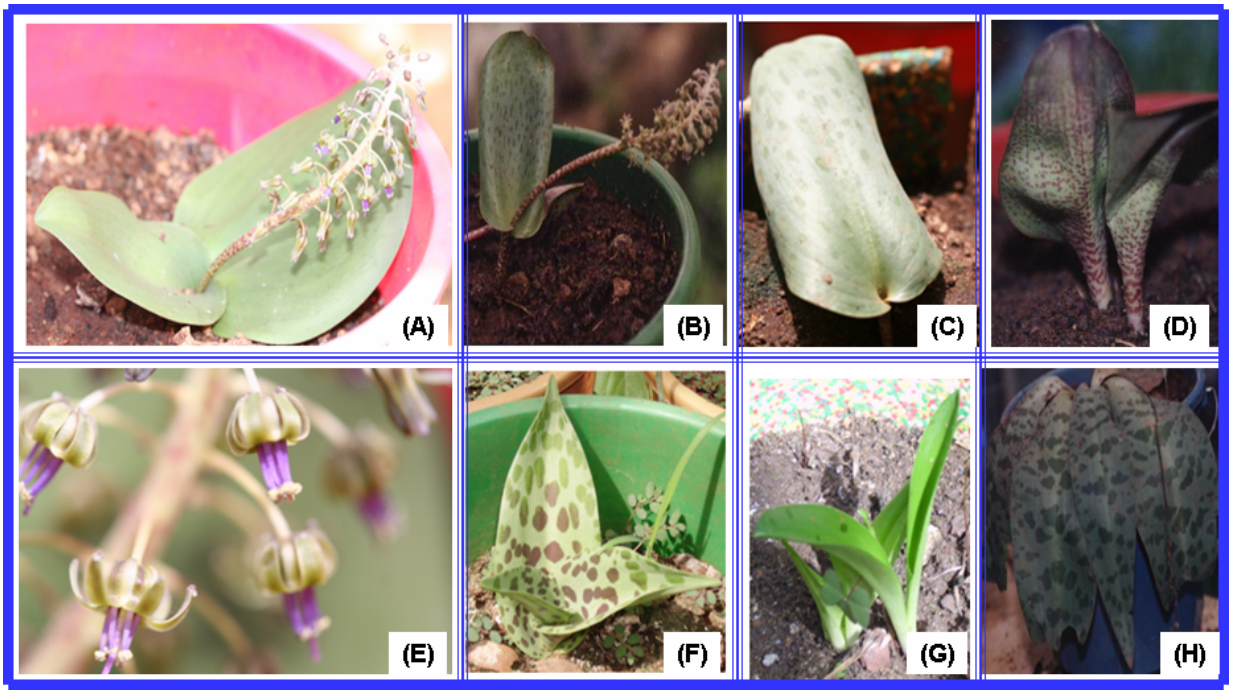

Figure 5. Variations in leaf spot color, leaf shape and other morphological features among *Ledebouria* species. A*) L. cordifolia* (Two Leaf), B-D) *L. cordifolia* (one leaf); E) degree of perianth segment reflection in most species of *Ledebouria* other than *L. urceolata,* F and G) *L. revolute,* H) *Ledebouria* sp

4.3 Morphological results obtained for *Drimiopsis*

Two, morphologically distinct, groups of *D. botyoides* were obtained in the study. One group had a cordate and mucronate leaves, which are almost as long as wide and with yellow flower color which is unusual in the genus. The other group had a lnaceolate and acute leaves with a higher leaf length to width ratio. These two groups are treated as *D. botryoides1* and *D. botryoides2*, respectively. Only a single specimen that represents the latter group is obtained in the herbarium. As a result statistical computation for it was difficult. For other taxa of the genus an independent-samples t test was computed.

The computed independent-samples t test clearly indicated that *D. spicata* and *D. botryoides*2 are significantly different from one another with respect to leaf number (P = 0.005), leaf width (P = 0.001), leaf length to width ratio (P = 0.038), number of flowers per inflorescence (P = 0.039), flower density (number of flowers within 2 cm inflorescence length) (P = 0.001), outer perianth width (P = 0.000), inner perianth width (P = 0.018) stamen length (P = 0.012) and peduncle number (P = 0.027). The summary of the morphological data generated for the genus is presented in Tables and in histograms as follows.

Table 9. Quantitative Morphological Characteristics of *Drimiopsis*

Species	*D. botryoides*2		*D. spicata*	
	Mean ± SD	Range	Mean ± SE	Range
Plant height (cm)	29.3 ± 5.13	25-35	30.5 ± 1.55	27-34
Leaf number	1.7 ± 0.577	1-2	3 ± 0.00	3
Leaf length (cm)	10.8 ± .289	10.5-11	14.25 ± 1.65	11-18
Leaf width (cm)	8.6 ± 1.52	7-10	2.875 ± 0.43	2-4
Leaf length to width ratio	1.3 ± 0.265	1.11-1.57	5.35 ± 1.22	4-9
Pseudopetiole length (cm)	0.7± 1.15	0-2	2.75 ± 0.83	1.5-5
Peduncle length (cm)	19.7 ± 3.055	17-23	18 ± 1.78	15-23
Peduncle number	1.7 ± 0.577	1-2	1 ± 0.00	1
Inflorescence length (cm)	5.7 ± 1.528	4-7	7.75 ± 1.89	3-12
Number of flowers per raceme	14.3 ± 5.13	10-20	33.25 ± 5.34	23-46
Number of flowers within 2 cm raceme length	5.7 ± 1.528	4-7	18.5 ± 1.32	15-21
Outer perianth width (cm)	0.2 ± 0.015	0.22-0.25	0.1075 ± 0.00	0.1-012
Inner perianth width (cm)	0.2 ± 0.006	0.16-0.17	0.152 ± 0.00	0.15-0.16
Stamen length (cm)	0.2 ± 0.010	0.14-0.16	0.1325 ± 0.00	0.13-0.14

Table 10: Qualitative Morphological Characteristics of *Drimiopsis*

Species	Leaf Shape	Leaf base	Leaf margin	Leaf apex	Inflorescence Type	Perianth color
D. botryoides1	Lanceolate	Cuneate	Entire	Acute	Spike	--
D. botryoides2	Cordate	Cuneate	Entire	Mucronate	Spike	Yellow
D. Spicata	Lanceolate	Cuneate	Entire	Acute	Spike	Bluish purple

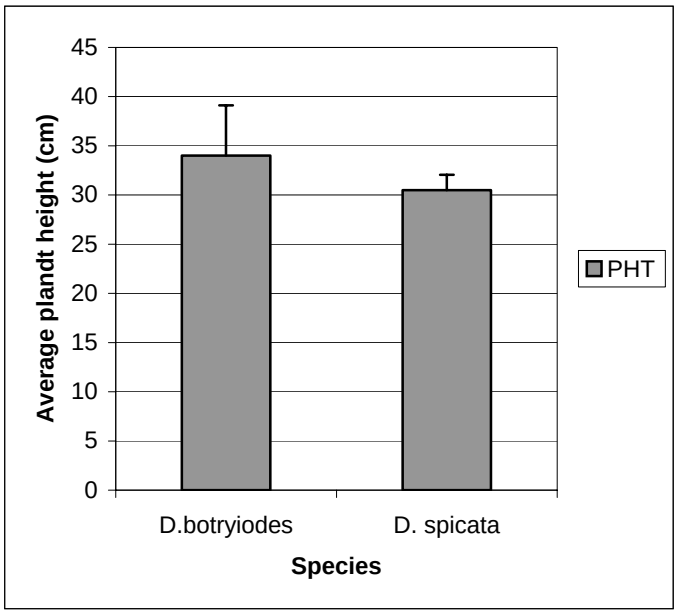

Figure 6. Average plant height (mean +/- SD)

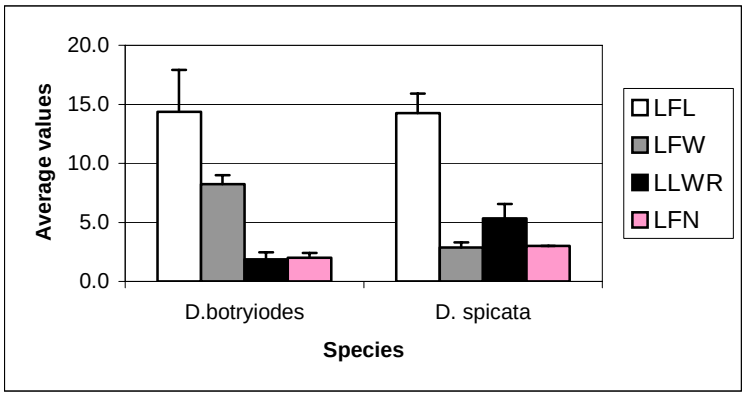

Figure 7. Mean values of leaf quantitative characteristics (mean +/- SD)

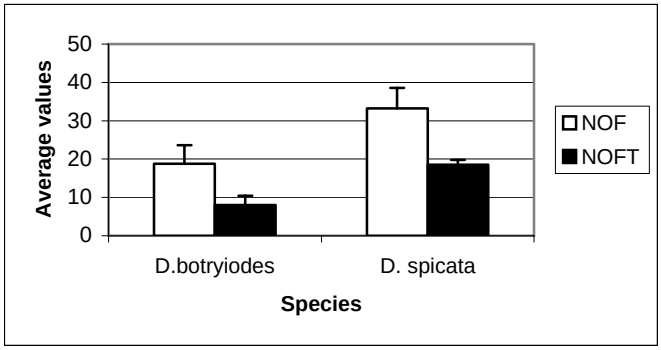

Figure 8. Average number of flowers per inflorescence (NOF) (mean +/- SD) and number of flowers within 2 cm inflorescence length (NOFT) (mean +/- SD).

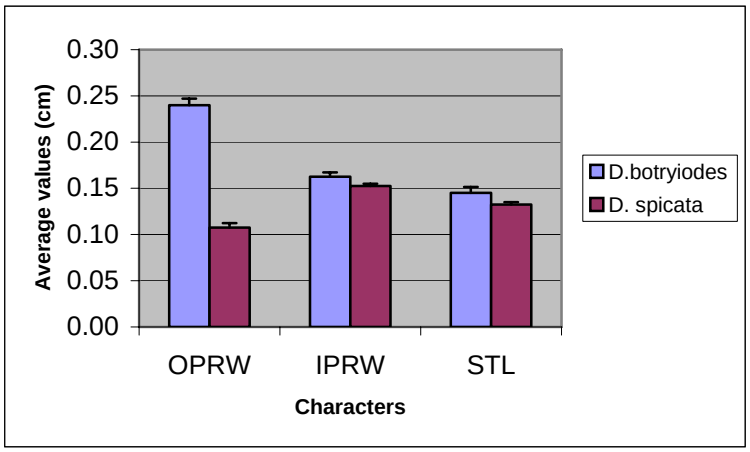

Figure 9. Average outer perianth width (OPRW), inner perianth width (IPRW) and Stamen length of *D. botryoides* and *D. spicata* (Mean ± SD).

4.4 Cluster analysis

A cluster analysis was made based on both the qualitative and quantitative morphological data generated for the *Drimiopsis* species following hierarchical cluster analysis procedure (NTSYS, Version 2:1) (Fig 9).

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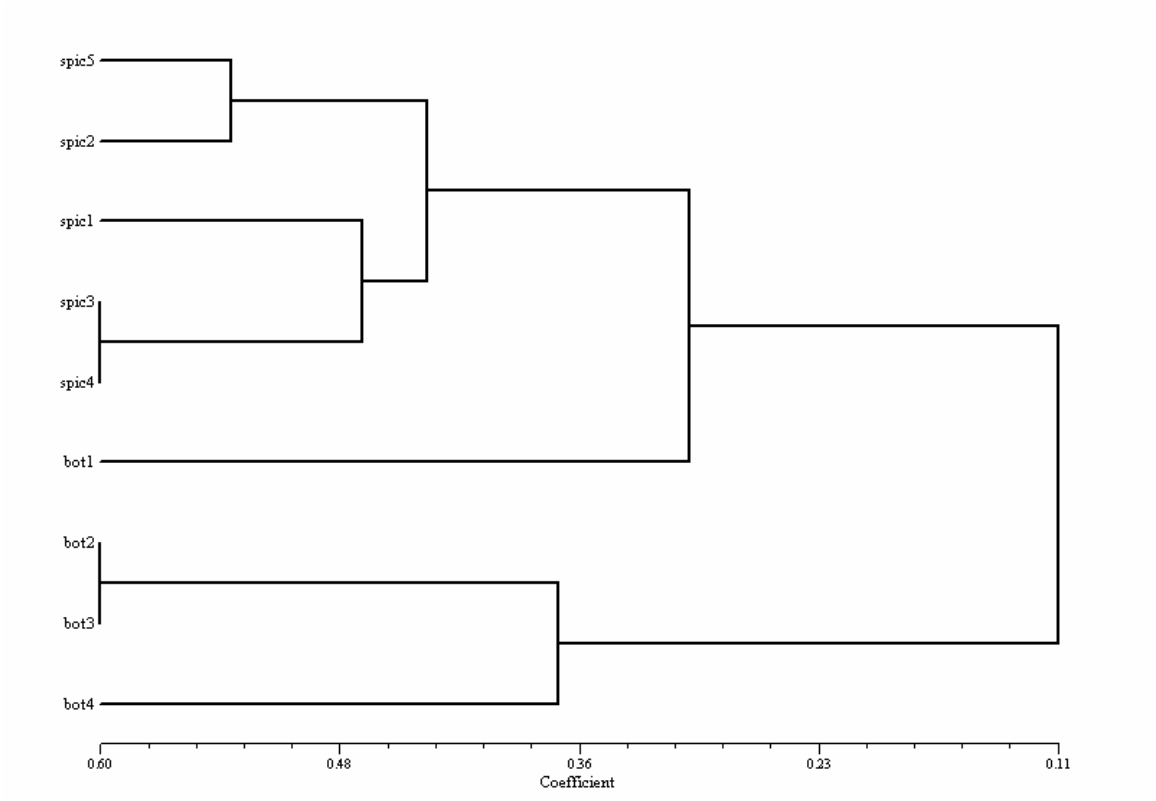

Figure 10. A Dendrogram constructed based on the combination of both qualitative and quantitative morphological characteristics of the genus *Drimiopsis* (spic = *D. spicata*, bot = *D. botryoides*). All the morphological characteristic features appearing on appendix 2 are taken into consideration.

A dendrogram constructed based on the qualitative and quantitative data resulted in grouping of the specimens studied for the genus *Drimiopsis* into three clusters at 0.36 similarity coefficient (Table 11).

Table 11. The Clusters Generated for *Drimiopsis* Species and Specimens Included in Each of the Clusters

Clusters	**Specimens**
Cluster I	bot2, bot3, bot4
Cluster II	bot1
Cluster III	spic5, spic2, spic1, spic3, spic 4

Figure 11. Pictures representing the two morphotypes of *D. botryoides*: A represents the specimen in cluster II (*D. botryoides1*) and B represents the specimens in cluster I or *D. botryoides2* (Table 11).

4.5 Chromosome number and karyotypic analysis

4.5.1 Chromosome number

Even though lots of trials were made, a well spread chromosome sets of the genus *Drimiopsis* could not be obtained. For the genus *Ledebouria*, variation in chromosome number and karyotype were observed from different specimens that are belonging to the same species. From five different specimens of *L. revoluta*, five different chromosomes numbers were counted (Table 12 and Figure 11). Similarly, two specimens of *L. cordifolia* that differ in leaf number also showed consistent difference in chromosome numbers (Table 12 and Figure 10).

Table 12. Chromosome numbers counted from different specimens of *Ledebouria*

Plant species	Plant Specimen	Somatic Chromosome number (2n)	Locality
L. revoluta	Tesfaye Awas 1155	38	Benishengul Gumuz, 5 km along the road from Kurmuk to Assosa
	Desalegn Chala 22	30	58 km from Dollo Mena, on the way to Bidre
	Sebsebe Demissew 6316a	*c* 20	Dilala, 39 Km from Waliso on the way to Addis Ababa
	Sebsebe Demissew 6316b	40	Dilala, 39 km on the way to Addis Ababa
	Tesfaye Awas 1159	44	Benishengul Gumuz
L.cordifolia	Desalegn Chala 10 (two leaf)	30	50 km E of Robe, on the way to Sof Umer cave
	Desalegn Chala 19 (two leafed)	30	74 E of Robe, on the way to Sofomer
	Desalegn Chala 14 (one leafed)	34	53 km E of Robe, on the way to Sof Umer cave

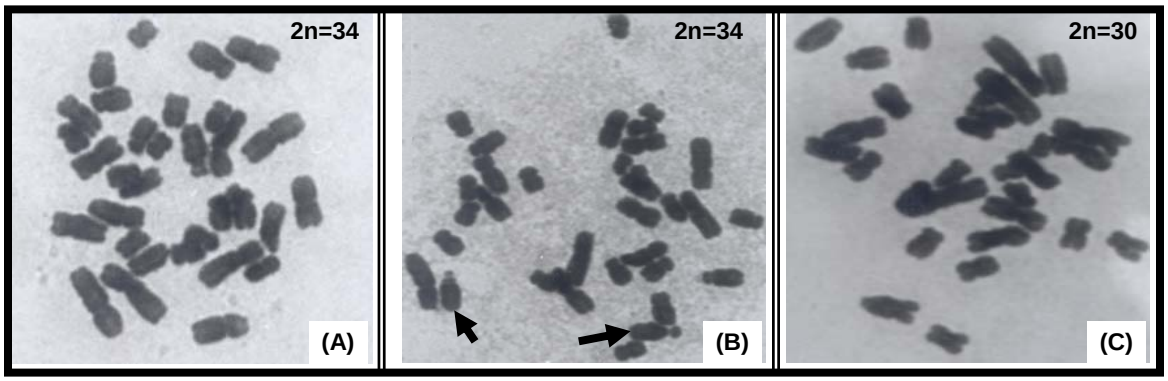

Fig 12. Photomicrographs of mitotic metaphase chromosomes of *L. cordifolia*: A and B) Desalegn Chala 14 (*L. cordifolia* with one leaf); C) Desalegn Chala 10 (*L. cordifolia* with two leaves).

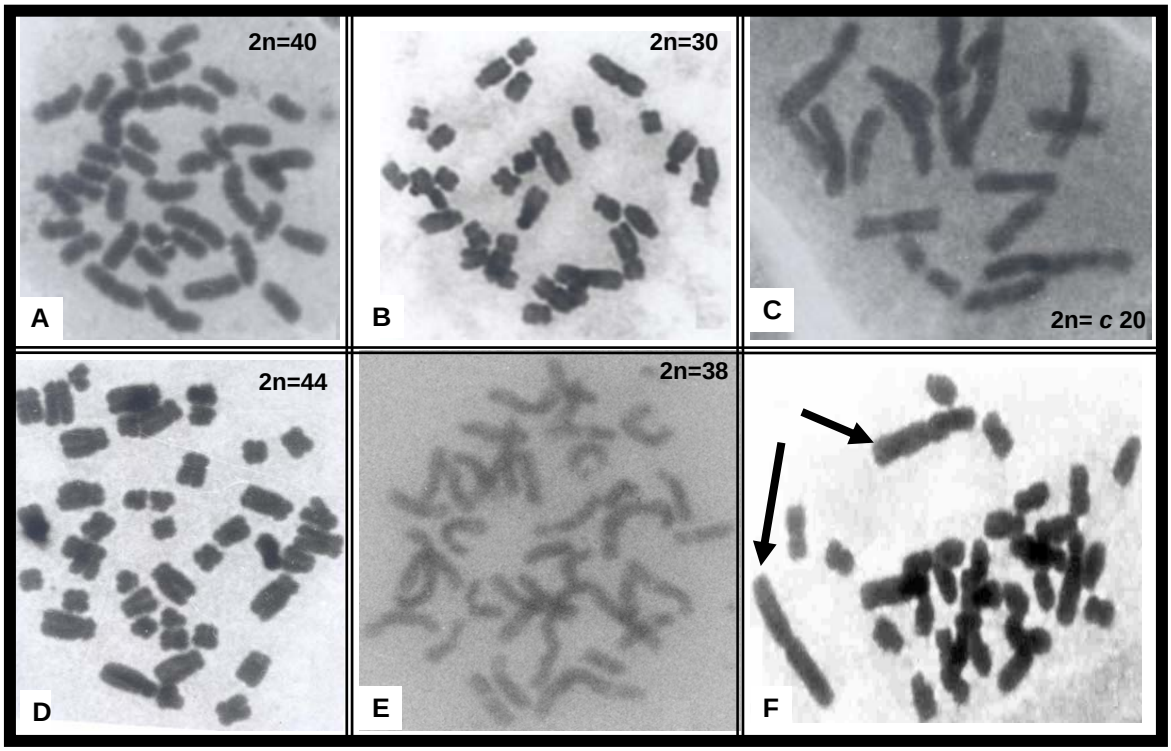

Fig 13. Photomicrographs of mitotic metaphase chromosomes of *L. revoluta*: A) Sebsebe Demissew 6316a; B) Desalegn Chala 22; C) Sebsebe Demissew 6316b; D) Tesfaye Awas 1159; E and F) Tesfaye Awas 1155. Arrows indicating the unusually large chromosomes.

4.5.2 Karyotype analysis

A well condensed and full spread chromosomes usable for karyotyping analysis for two cytotypes, 2n = 38 and 2n = *c* 20, of *L. revoluta* could not be obtained. Thus doing the karyotype of the two cytotypes of *L. revoluta* was difficult. For other specimens of the two species, the karytype analysis are summarized and presented in Table 13 and Figure12.

Table 13. Summary of karyological data of the specimens examined for the genus *Ledebouria* (M = median point, m = median region, sm = sub median region and st = sub terminal region.

			Karyotype features					
			Size		Centromeric position			
Species	Voucher specimen	Diploid number	Longest chr.(µm)	Shortest chr. (µm)	M	m	sm	st
L. cordifolia	Desalegn Chala 10	30	7.7	2.4		7 (46.7%)	7 (46.7%)	1 (6.6%)
	Desalegn Chala 14	34	7	1.9	2 (11.8%)	5 (29.4%)	7 (41.2%)	3 (17.6)
L.revoluta	Desalegn Chala 22	30	5.8	1.7		10 (66.7%)	2 (13.3%)	3 (20%)
	Sebsebe Demissew 6316b	40	6.6	3	3 (15%)	14 (70%)	3 (15%)	
	Tesfaye Awas 1159	44	6.6	2.4		10 (45.5%)	7 (31.8%)	5 (22.7%)

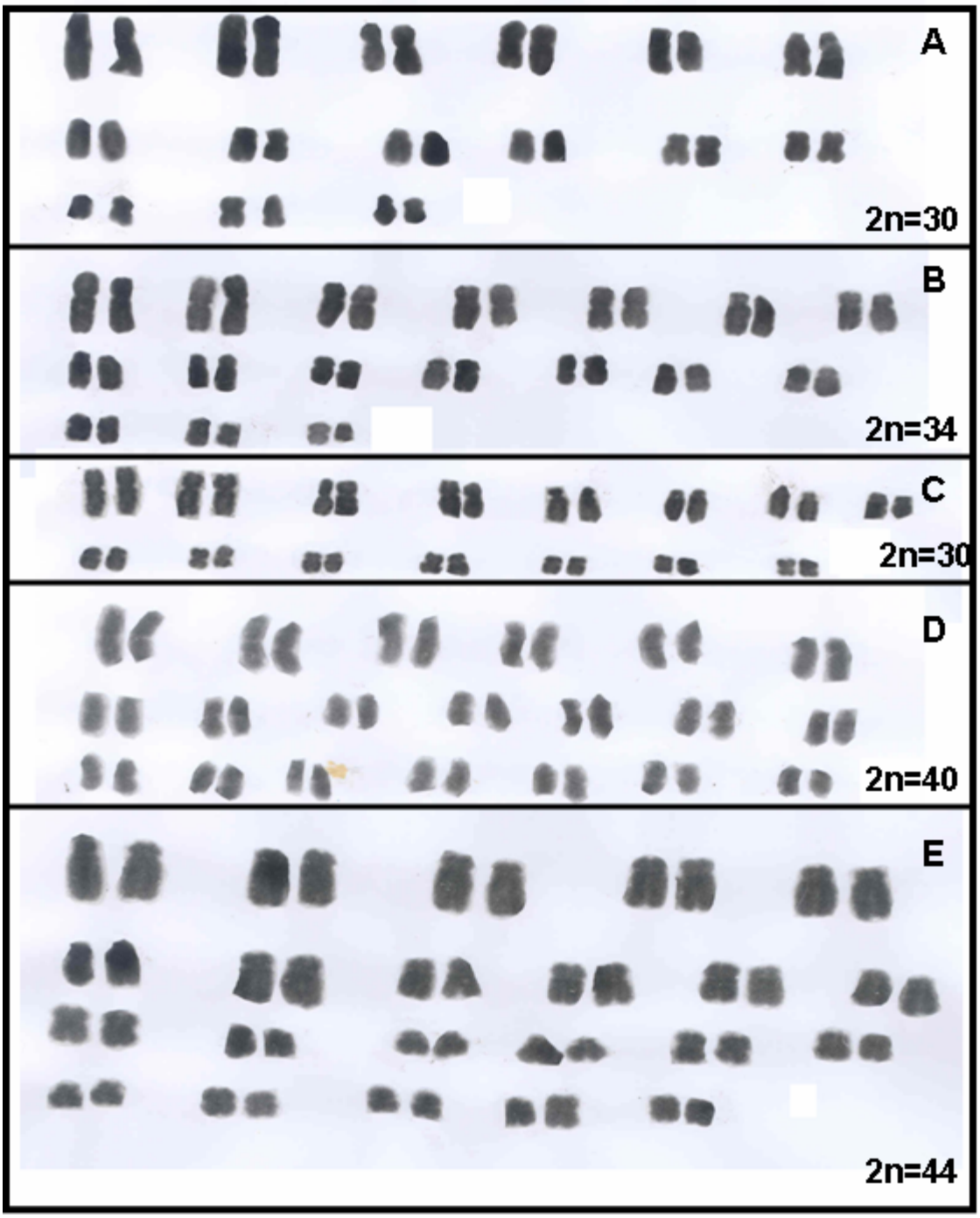

Fig 14. Karyotypes of *Ledebouria*: A) *L. cordifolia* (two Leaves)-Desalegn Chala 10; B) *L. cordifolia* (one leaf)- Desalegn chala 14; C-F) *L. revoluta*- C) Desalegn Chala 22, D) Sebsebe Demissew 6316b and F) Tesfaye Awas 1159.

5. DISCUSSION

5.1 *Ledebouria*

In the genus *Ledebouria*, based on the morphological characteristic features, there are five groups (clusters) that could easily be recognized. Cluster I exclusively included *L. somaliensis* while cluster II included all the specimens of *L. kirkii* and a single specimen of *L. revoluta*. The specimen of *L. revoluta* (revo17), which is clustered with *L. kirkii*, has longer perianth length (7 mm) and wider non-spotted leaves (4 cm) as compared to other specimens of *L. revoluta*. *L. kirkii* is separated from *L. revoluta* by its longer perianth length (Thulin, 1995; Stedje, 1996a and Stedje, 1997) and also has wider leaves as compared to *L. revoluta*. However the perianth length of this specimen is less than that of the specimens of *L. kirkii* and does not fall within the perianth length range of *L. kirkii*.

The chromosome number recorded for this specimen, the specimen of *L. revoluta* clustered with *L. kirkii*, is 2n = 30. But, the difference in chromosome number and karyotype within *L. revoluta* is very common (Jessop 1972; Stedje, 1996b). As a result, it is difficult to boldly claim about the taxonomic position of the specimen based on chromosome number and karyotyping.

In the dendrogram constructed based on overall morphological characteristics, the close relationship between *L. somaliensis* and *L. kirkii* was clearly observed. The computed one way ANOVA also clearly indicated that *L. somaliensis* was closely related to *L. kirkii* and significantly different from other species of *Ledebouria* with regard to plant height, leaf number, leaf width and perianth length. But, no obvious discontinuity with respect to

most of the aforementioned morphological characteristic features between the two taxa and other species of *Ledebouria* was observed. The range in perianth length is the only characteristic feature that showed obvious gap and distinguished the two taxa from other species of the genus. So, perianth length can be used as a key characteristic feature to distinguish the two taxa from others.

L. kirkii also significantly differed from all others with respect to pedicel length. But, the pronounced difference in pedicel length was found between *L. kirkii* and *L. somaliensis*. *L. kirkii* had the highest average pedicel length while *L. somaliensis* had the lowest. A clear gap and discontinuity in the characteristic feature is also observed between the two taxa. So, pedicel length can be used to distinguish between the two species.

These characteristic features that are found to be important in distinguishing *L. somaliensis* and *L. kirkii* from others and to distinguish between *L. somaliensis* and *L. kirkii* are also mainly used as key diagnostic features to serve such taxonomic purposes in different Floras (Thulin, 1995; Stedje, 1996a and Stedje, 1997).

Cluster III contained a single specimen of *L. revoluta*, which appeared as a separate group to other specimens of *L. revoluta*. This specimen (revo1) is characterized by larger perianth and stamen length as compared to most of specimens examined for *L. revoluta*. That must be the probable reason why it appeared as a separate group to other specimens of *L. revoluta* and more correlated with the specimens of *L. kirkii* and *L. somaliensis*.

Cluster IV contained mixtures of most specimens of *L. revoluta* and all specimens of *L. urceolta*. *L. urceolta* intruded between specimens of *L. revoluta* dividing them into two subgroups. Hence, the computed cluster analysis could not support recognizing *L. urceolata* as a separate taxon. A strong morphological relationship between the two taxa was also observed in the computed one way ANOVA. They significantly differed from each other only with respect to plant height and perianth width. The close relatedness of *L. urceolta* with most of *L. revoluta* was also found to be higher than the degree of similarity that was found within *L. revoluta* itself. Stedje and Thulin (1995) also revealed the morphological close relationship between the two taxa.

However, with respect to karyotpe, *L. urceolata* is reported to be highly different from *L. revoluta* (Stedje, 1996b). Even though variation in karyotype is commonly found even among the different cytotypes of *L. revoluta* (Jessop, 1972), the karyotypic difference between the two taxa is also further strengthened by DNA sequence data and a DNA sequence data pooled with morphological data (Stedje, 1998). In the cladistic analysis made based on these data, Stedje (1998) found that *L. somaliensis* intervened between the two species with a higher bootstrap value which indicates that *L. urceolta* is more closely related to *L. somaliensis* than to *L. revoluta*.

Stedje (1998) also indicated that *L. revoluta* is the most complex species and reported to appear as a paraphyletic group with a high in-group divergence, a divergence that is comparably found between the genera *Ledebouria* and *Drimiopsis*. The cladistic analysis computed based on the morphological data also indicated the complexity of *L. revoluta*

and this is further strengthened by the chromosome number and karyotype differences within the taxon. 2n= *c* 20, 30, 38, 40 and 44 are the chromosome numbers recorded for *L. revoluta* in the present study. The chromosome numbers 2n = *c* 20 and 30 agree to the haploid chromosome numbers reported by Jessop (1972) from South African material of the species. n = 9, 10, 11, 12, 13, 15, 16, 17 and 18 were the series of haploid chromosome numbers reported by him. Thus, the chromosome numbers 2n = 38, 40 and 44 reported here will be the new chromosome numbers to be documented for the taxon.

Even though most of the chromosomes of each cytotypes reported in this study had mainly chromosomes with centromeres in the median region, a great variation in chromosome size range and centromeric position was clearly observed.

The larger chromosomes of the 2n = 44 cytotype have centromeres mainly at sub terminal and sub median regions which is unusual in others. Even though about 66% and 70% of the chromosomes of the 2n = 30 and 2n = 40 cytotypes have centromeres at the median region respectively, only about 44.5% of the chromosomes of the 2n = 44 cytotype have centromeres at a similar position (Appendix 6).

Although the karyotypes of 2n = 30 and 2n = 40 relatively seem to share some similarities, they are also very different. The 2n = 30 has three pairs of chromosomes with centromeres at sub terminal region and no chromosomes with centromres at median point. But, the reverse is true for the 2n = 40 cytotype.

The 2n = 38 cytotype also has one pairs of unusually large metacentric chromosomes. In other cytotypes of *L. revoluta*, the entire chromosome length ranges to 6.6 μm. But, in case of the 2n = 38 cytotype, the largest chromosomes pair has a size of 11 μm which is almost twice as large as the largest chromosome pair of other cytotypes (Fig 13).

Such numerical and structural variations might suggest reproductive isolation and as a result the plants might belong to different biological species. Hence, studies in the line of meiotic pairing and crossing experiments among these different cytotypes are highly recommendable.

The chromosome numerical and structural variations can also be linked with the reduction in fertility. In *Ledebouria*, seeds are set in a very small percentage, in about 1% of the flowers (Jessop, 1972). According to Jessop (1972) hand pollination (both self and cross) could not increase the number of seeds set per flower. One explanation in defining species in the genus may also be the predominance of non-sexual reproduction. The numerical changes might also be because of dysploidy change or aneuploidy. As a result doing flowcytometry or genomic quantification for the genus and for the species having different chromosome numbers without showing any trend in ploidy levels and morphological discontinuity is one of the options that can be recommended. Especially, if the variation is because of dysploidy change, genomic quantification can indicate certain trend in ploidy levels and thus may solve the taxonomic problem of the taxon.

Stedje (1997) treated *L. urceolata* to have wider perianth length (*c* 3mm) and higher perianth length to width ratio and a perianth segments refelexed at their tips. She also used these characteristic features to distinguish *L. urceolata* from *L. revoluta*. Even though the two species significantly differed in plant height and perianth width, no obvious gap in the perianth width and peianth length to width ratio was observed. The only diagnostic feature that differentiated *L. urceolta* from *L. revoluta* and other species of the genus is found to be the degree of perianth segment reflection. In all representative of the genus, the tepals reflex for more than half of their length. But, in *L. urceolata* the perianth segments reflex only at their tip giving the plants a pot like shape.

Cluster V exclusively contained specimens belonging to *L. cordifolia*. The cladistic analysis also clearly revealed that *L. cordifolia* is morphologically a very distinct group that is separated from all other taxa in the genus at 0.67 dissimilarity ratio. It is different from all others in leaf characteristic features like leaf number, leaf shape, leaf apex and a cordate leaf base clasping the brown spotted scape which is unusual in the other species of the genus. The leaves are also usually narrowed into a true petiole, which is also not common in other species of *Ledebouria*.

L. cordifolia also had the highest average leaf width and the lowest average leaf number and leaf length to width ratio even though no gap and discontinuity in the range of these characteristic features that let one use as diagnostic features to distinguish the taxon from others were observed. The leaves of the plants under the taxon were only about 1.5 times

longer than wide on average. But, all other species of the genus had an average leaf length to width ratio of greater than two.

There is no chromosome number and karyotype reported for *L. cordifolia* so far. In the present study, two chromosome numbers, 2n= 30 and 34 were recorded for the taxon. Even though variation in basic number within a genus and species were commonly reported for species of *Ledebouria* and other related genera, a remarkable morphological differences and discontinuities were not reported for materials belonging to the same species having different chromosome numbers (Jessop, 1972 and Stedje, 1996b).

However, incase of *L. cordifolia*, the difference in chromosome number was accompanied by the difference in karyotyping and morphology, leaf number. With regard to karytyping, the two cytotypes differed both in chromosome size range and in centromere position (Table 13). A consistency in chromosome number and karyotype difference between the two morphotypes, one leafed and two leafed specimens, has also been proven through repetitive experiments. Thus, even though the need for further study is there, splitting the taxon into two different taxa seems reasonable.

Jesssop (1972) claimed that only few South African species of *Ledebouria* were defined based on satisfactory amount of quantitative data. Even though very little variations and discontinuities were also observed for the Ethiopia species of the genus, based on the current study the following key can be made.

1 Perianth length 9 mm more above	2
Perianth length up to 8 mm	3
2 Pedicels up to 4 mm long	*L. somaliensis*
Pedicels 5 mm or above	*L. kirkii*
3 Leaves cordate, mucronate, clasping the leafless scape	*L. cordifolia*
Leaves narrowly or broadly lanceolate, acute	4
Perianth segments reflex for more than half of the entire length	*L. revoluta*
4 Perianth segments reflex only at their tips	*L. urceolata*

5.2 Drimiopsis

D. botryoides is described to have greenish-white tepals (Thulin, 1995; Stedje, 1996a and 1997). Greenish-white tepal is also a flower color that is conserved within the genus *Drimiopsis*. However, most of the herbarium materials of *D. botryiodes* were found to have a bizarre flower color, yellow, which is not found in any taxon of the genus. Moreover, the leaves of the species is described as ovate to broadly elliptic *c* 18 x 8 cm (Thulin, 1995), lanceolate to broadly lanceolate, up to 17 x 8 cm (Stedje, 1997) and cordate to lanceolate, up to 45 x 1.5-7.5 cm (Stedje, 1996a). But, the herbarium materials of the taxon used in this study had cordate leaves of *c* 11 x 9 cm. The leaf length and width are almost equal and near to 1:1 in ratio which is unusual to other materials of the taxon. The materials used in the study were mainly two leafed. The inner leaf is small and clasps the scape like the case in two-leafed *L. cordifolia*.

So, such differences in both the floral characteristic (floral color) and leaf characteristics might suggest the materials may belong to another taxon. This indicates the need to check the type specimen of the species and compare the specimens from our area with specimens from other areas in order to determine the taxonomic identity of these materials.

Stedje (1994) observed a morphologically distinct group of *D. botryoides* from Tanzania which were small plants up to 15 cm long, with cordate to broadly lanceoltae leaves having flowers with sessile or very short pedicel and considered it as *D. botryoides* ssp *prostrata*. This group seems morphologically more similar to the herbarium materials studied. But, there is no description regarding flower color, leaf length and width of the group. The only chromosome number recorded for the group so far is 2n = 22 (Stedje, 1994). As a result, checking the type specimen of this taxon and working on the chromosome cytology of the Ethiopian plants may also help a lot to determine their taxonomic identity.

Another herbarium material belonging to *D. botryoides*, bot1 (Sebsebe Demissew, C. Hermann and Tesfaye Awas, 5999) was also found to be morphologically very different from the above materials. Morphologically, this specimen fits with the description of the species in the Flora of Ethiopia and Eritrea (Stedje, 1997). The floral color of the material could not be clearly seen from the dried herbarium specimen. The material is related to *D. spicata* in leaf shape, leaf length, and leaf width and plant height. But, unlike in *D. spicata*, in the material only the inner perianth connivents and the inner perianth

segments are narrower than the outer. So, this material seems to be the true *D. botryoides* material on which the description in the Flora was based.

Oyewole (1984b) revealed that plants of the species *D. barteri* are sexually sterile. Similarly Stedje (1994) carried out crossing within and between four populations of East African *Drimiopsis* and obtained *D. barteri* is self-incompatible and *D. botryoides ssp botryoides* is self-compatible. Several attempts made to cross *D. barteri* (2n = 44) and the 2n = 44 cytotype *D. botyroides* failed (Stedje, 1994), which indicates the two taxa are not only two morphological but also two biological species. But, she was successful in crossing between ploidy levels of *D. botryoides*, which might indicate the presence of some gene flow between the ploidy levels. Crossing *D. spicata* with its respective cytotype of *D. barteri* and *D. botryoides* might also have a contribution to establish the taxonomic relationships of the taxa.

5.3 Generic Delimitation Between the Two Genera

Unlike the other species of *Ledebouria*, *L. urceolata* has pot shaped flower, which looks like the connated flowers of *Drimiopsis*. On the other hand, *D. spicata* has a bluish purple flower, which is nearly similar to the purple flower of *Ledebouria*. As a result, the two species were considered as the species that probably bridge the two related genera (Sebsebe Demissew *et al*., 2003). But, the dendrogram constructed based on the overall morphological data clearly indicated that the two genera are not morphologically closely related and the two species do not bridge the two genera (Fig, 14).

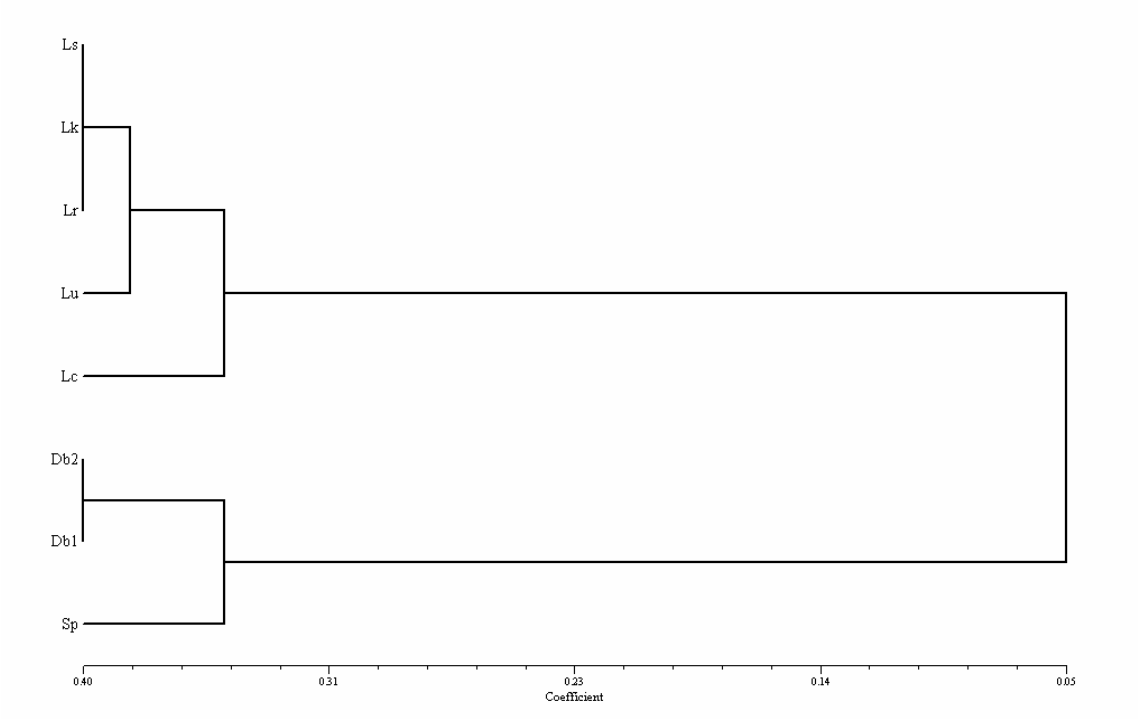

Fig 14. A dendrogram constructed based on the overall morphological data (Ls = *L. somaliensis*, Lk = *L. kirkii*, Lr = *L.revoluta*, Lu = *L. urceolata*, Lc = *L. cordifolia*, Db2 = *D. botryoides2* (yellow flowered), Db1= *D. botryoides1*, Sp= *D. spicata*). The lists of the characteristic features used here are presented in appendix….

But, morphological distinctiveness of the two genera is not supported by the molecular works done so far (Stedje, 1998; Pfosser and Speta, 1999; Manning *et al*., 2004). But, all these authors depended on cpDNA to generate the molecular data.

However, cpDNA is generally characterized as structurally stable, haploid, non-recombinant and generally uniparentally inherited. Structural stability across large evolutionary scale has also been demonstrated by comparative cpDNA mapping and sequencing and numerous studies have shown that cpDNA molecules are highly

conserved with respect to gene content and arrangement at lower taxonomic levels, especially among closely related species (Olmstead and Palmer, 1994).

Because of its haploid nature and uniparental inheritance, cpDNA reveals only half of the percentage in plants of hybrid or polyploidy origin. Thus, cpDNA analysis of hybrid or polyploid plants may incorrectly identify them as belonging to a clade of one of the two parents, without revealing the hybrid history (Small *et al*., 1998). This fact is another potential draw back of solely depending on cpDNA for plant molecular systamatics.

Given the small rate of cpDNA evolution, even non-coding cpDNA regions are also reported to often fail to provide significant phylogentic information at lower taxonomic levels (Small *et al*., 1998). As a result, cpDNA is mainly recommended to be used at family level and above (Chase *et al*., 1993; Qiu *et al*., 1999; Soltis *et al*., 1999).

To compensate for the limitations of cpDNA as well as to obtain additional independent estimate of phylogeny, nuclear DNA is widely adopted as a tool in plant systematics, especially at lower taxonomic levels (Baldwin *et al*., 1995; Alvaraz and Wendel, 2003). So, before boldly claiming the monophyly of the two genera, using nuclear DNA for systematic work of the taxa, instead of solely depending on cpDNA, is one of the options that can be recommended to resolve the taxonomic confusion of the taxa.

6. CONCLUSIONS AND RECOMMENDATIONS

The morphological close relationship between *L. revoluta* and *L. urceolata* (Stedje and Thulin, 1995) and the variation in karyotype and morphological complexity found within *L. revoluta* (Stedje, 1996b) were revealed in the dendrogram constructed based on the overall morphological data and in the chromosome number and karyotyping done for the taxon.

For *L. revoulta*, there is a lack of chromosome number consistency and great structural variations among different cytotypes without any morphological discontinuities. No basic number and ploidy level series can be suggested from the present study and the studies done so far. The numerical and chromosome structural variations among different cytotypes might suggest reproductive isolation and as a result the plants might belong to different biological species. Hence, studies in the line of meiotic pairing and crossing experiments among these different cytotypes are highly recommendable. The numerical and structural changes of chromosomes might also occur because of dysploidy changes or aneuploidy. As a result genomic quantifications or flowcytometry works may also indicate certain trend in ploidy levels and thus may solve the taxonomic problem of the taxon.

Two new chromosome numbers, 2n = 30 and 2n = 34 were obtained for *L. cordifolia* in the current study. There is a clear morphological discontinuity and a difference in karyotype between the two cytotypes. Even though the taxon can potentially be separated

in two taxa, further studies on materials from other areas, including the type, is highly recommendable.

Most of the herbarium specimens identified as *D. botyoides* and used in the study had a unique flower color that is not common in the taxon and the genus. Even though greenish white flower color is conserved in the genus, these materials had a yellow flower color. The other morphological characteristic features of these materials do not also go with the description of *D. botryoides* in different Floras including the Flora of Ethiopia and Eritrea. This calls for studies to look at the variation of the species throughout its distribution range in order to determine the identity of this taxon. Further chromosome cytology and molecular works for the species in the genus are also highly recommendable both to resolve the taxonomic problems and to serve as base line information.

Most species under the two genera, *Ledebouria* and *Drimiopsis*, are poorly described with regard to fruit and seed characteristic features. Since the herbarium materials mainly lack these features, the problem could not be solved in this study too. Thus, there is a need to collect seeds and fruits of the taxa.

Even though the presence of *L. edulis* is mentioned in the Flora (FEE), no herbarium collection of it was obtained in the current study. As a result, there is a need for collections and morphological and chromosome cytological studies are requaired.

The genera *Ledebouria* and *Drimiopsis* are morphologically very distinct groups. However, recognizing them as separate taxa is not supported by the molecular works done so far (Stedje, 1998; Pfosser and Speta, 1999; Manning *et al*., 2004). But, all these authors depended on cpDNA to generate the molecular data.

However, cpDNA is highly evolutionary conserved and is not recommendable to be used alone, especially at lower taxonomic levels. There for, using nuclear DNA for systematic work of the taxa instead of solely depending on cpDNA might help to resolve the taxonomic confusion of the taxa, which is highly recommended.

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8. Appendices

Appendix 1. Specimens of the genus Ledebouria that are examined in the study

Asgjhmnl;;lk

eeeeeeee

Appendix 2. Specimens of the genus Drimiopsis that are considered in the study

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rerthhg

Appendix 3. Test of Homogeneity of Variances (unequal variances) for species of Ledebouria.

	Levene Statistic	df1	df2	Sig.
Leaf number	4.272	4	36	0.006
Leaf length to width ratio	4.929	4	36	0.003
Number of flowers per raceme	3.084	4	30	0.031
Perianth width	5.572	4	29	0.002
Perianth length	6.002	4	29	0.001
Perianth length to width ratio	2.693	4	29	0.051
Stamen length	5.897	4	29	0.001
Pistil length	5.648	4	29	0.002

Appendix 4: Test of Homogeneity of Variances (equal variances) among specimens examined for the genus *Ledebouria.*

	Levene Statistic	df1	df2	Sig.
Plant height	1.471	4	30	0.236
Leaf length	2.543	4	36	0.056
Leaf width	1.504	4	36	0.222
bPseudopetiole length	2.432	4	30	0.069
Peduncle length	1.142	4	30	0.356
Peduncle number	1.293	4	28	0.297
Raceme length	1.159	4	30	0.348
Number of flowers within two cm raceme length	1.431	4	30	0.248
Pedicel length	10.260	4	29	0.000

Appendix 5. Mean and standard deviations of different morphplogical characteristic features seen for the genus *Ledebouria* and the species included in it (the designations of each symbols are found on Table 5).

SPECIES	L. somaliensis		L. kirkii		L.cordifolia		L. revoluta		L. urceolta		Total	
	Mean	SE	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
alt	905.	175	423.33	37.12	1836.00	61.45	1325.5	142.88	264	48.48	1490.85	114.07
pht	34.0 ± 2.7	2.68	32.0 ± 4.0.	4.00	21.1 ± 2.1	2.14	22.9 ± 1.0	1.03	13.4 ± 1.5	1.47	24.00	1.33
lfn	5.2 ± 0.3	0.31	3.0 ± 1.5	1.53	1.5 ± 0.2	0.17	3.5 ± 0.3	0.31	3 ± 0.3	0.32	3.17	0.25
lfl	11.1 ± 0.8	0.79	15.6 ± 0.3	0.33	9.0 ± 0.7	0.65	10.3 ± 0.8	0.81	8.4 ± 2.5	2.49	10.25	0.54
lfl	4.6 ± 0.3	0.34	3.7 ± 0.2	0.17	6.2 ± 0.5	0.46	2.5 ± 0.2	0.24	1.8 ± 0.3	0.28	3.71	0.30
llwr	2.4 ± 0.3	0.29	4.3 ± 0.3	0.27	1.5 ± 0.13	0.13	4.7 ± 0.6	0.59	4.2 ± 1.0	1.09	3.52	0.35
ptl					4.8 ± 0.9	0.89					4.75	0.89
sptl	1.9 ± 0.3	0.30	5.5 ± 0.3	0.29	2.1 ± 0.6	0.63	3.6 ± 0.4	0.44	3.56 ± 0.94	0.94	3.27	0.31
pdl	15.8 ± 1.4	1.38	17.3± 1.9	1.86	13.5± 1.9	1.85	11.0± 0.9	0.93	9.2 ± 3.6	3.56	12.41	0.84
pdn	2.7± 0.6	0.56	1.5± 0.5	0.50	1.5 ± 0.5	0.50	1.8± 0.16	0.16	2 ± 0.3	0.32	1.94	0.16
rcl	14.2 ± 1.6	1.62	11.2 ± 3.2	3.19	6.8 ± 0.8	0.78	7.9 ± 0.8	0.80	5.6 ± 1.1	1.13	8.83	0.72
nof	61.2 ± 4.3	4.27	37.7± 8.3	8.29	40.5± 3.4	3.43	44.5 ± 4.6	4.55	31.8 ± 3.1	3.12	44.49	2.84
noft	13.7 ± 1.1	1.05	9.0± 0.6	0.58	14.3 ± 0.9	0.85	15.2 ± 0.9	0.93	15.0 ± 0.95	0.95	14.29	0.58
pdcl	0.3± 0.03	0.03	1.3 ± 0.35	0.35	0.65 ± 0.05	0.05	0.5 ± 0.04	0.04	0.5 ± 0.0	0.05	0.55	0.06
prw	0.2 ± 0.02	0.02	0.16 ± 0.01	0.01	0.17 ± 0.02	0.02	0.14 ± 0.01	0.01	0.2 ± 0.0	0.00	0.16	0.01
prl	0.97 ± 0.03	0.03	0.97 ± 0.07	0.07	0.63± 0.05	0.05	0.48 ± 0.03	0.03	0.5 ± 0.0	0.00	0.63	0.04
plwr	7.1 ± 1.2	1.15	6.0 ± 0.3	0.33	3.8 ± 0.7	0.68	3.6 ± 0.3	0.29	2.5 ± 0.0	0.02	4.29	0.36
stl	0.93 ± 0.06	0.06	0.7 ± 0.2	0.20	0.45± 0.03	0.03	0.4± 0.03	0.03	0.5 ± 0.0	0.00	0.56	0.04
psl	0.8 ± 0.07	0.07	0.7 ± 0.2	0.21	0.43 ± 0.03	0.03	0.3 ± 0.03	0.03	0.41 ± 0.0	0.02	0.50	0.04

Appendix 6. Size of each chromosome pairs of the different cytotypes of *Ledebouria* examined in the study in ascending order (tl = Total chromosome length, l = Length of the longest arm, s = lengh of the shortest arm, r = arm ratio (l/s)).

A) *L. cordifolia* (two leaf)-Desalegn Chala 10, 2n = 30

Chromosome pairs	tl	l	s	r	centromeric postion
1	7.7	4.8	2.9	1.6	m
2	7.4	6.0	1.3	4.5	st
3	5.7	3.2	2.5	1.3	m
4	5.4	3.3	2.1	1.5	m
5	5.0	3.3	1.7	1.9	sm
6	4.9	3.5	1.4	2.4	sm
7	4.4	3.6	0.8	4.4	st
8	3.8	2.5	1.3	1.9	sm
9	3.7	2.7	1.0	2.6	sm
10	3.6	2.6	1.0	2.6	sm
11	3.6	2.0	1.6	1.2	m
12	3.5	1.9	1.6	1.1	m
13	3.3	1.7	1.6	1.1	m
14	2.9	1.6	1.3	1.3	m
15	2.4	1.6	0.8	2.1	sm

B) *L. cordifolia* (two leaf) Desalegn Chala 14, 2n = 34

Chromosome pairs	tl	l	s	r	Centromeric postion
1	7.0	4.4	2.6	1.7	m
2	6.9	4.2	2.7	1.5	m
3	5.2	3.6	1.6	2.3	sm
4	4.8	2.4	2.3	1.0	M
5	4.7	2.6	2.1	1.2	m
6	4.7	3.7	1.0	3.7	st
7	4.4	2.9	1.5	1.9	sm
8	4.1	3.1	1.0	2.9	st
9	3.7	2.6	1.1	2.3	sm
10	3.5	1.8	1.7	1.0	M
11	3.5	2.3	1.2	2.0	sm
12	3.4	2.0	1.4	1.4	m
13	3.4	2.2	1.2	1.9	sm
14	3.3	2.5	0.6	4.3	st
15	3.1	2.5	0.7	3.8	st
16	3.1	2.2	0.9	2.5	sm
17	1.9	1.0	0.9	1.1	m

C) *L. revoluta*-Desalegn Chala 22, 2n = 30

Chromosome pairs	tl	l	s	r	centeromere postion
1	5.8	3.3	2.5	1.4	m
2	5.1	3.1	2.0	1.6	m
3	4.1	2.1	1.9	1.1	m
4	4.1	2.3	1.8	1.3	m
5	4.0	3.1	0.9	3.4	st
6	3.7	3.1	0.6	5.3	st
7	3.2	2.5	0.7	3.8	st
8	2.5	1.5	1.0	1.5	m
9	2.4	1.6	0.8	1.9	sm
10	2.3	1.3	1.0	1.3	m
11	2.2	1.6	0.7	2.3	sm
12	2.2	1.2	1.0	1.2	m
13	1.9	1.1	0.8	1.3	m
14	1.8	1.0	0.8	1.2	m
15	1.7	1.0	0.7	1.5	m

D) *L. revoluta*- Sebsebe Demissew 6316b, 2n = 40

Chromosome pairs	tl	l	s	r	Centromeric postion
1	6.6	3.6	3.0	1.2	m
2	6.4	3.2	3.2	1.0	M
3	5.6	2.8	2.8	1.0	M
4	4.9	3.4	1.5	2.3	sm
5	4.8	3.1	1.7	1.9	sm
6	4.6	2.7	1.8	1.5	m
7	4.3	2.5	1.8	1.4	m
8	4.1	2.5	1.6	1.6	m
9	3.9	2.1	1.9	1.1	m
10	3.9	2.2	1.7	1.3	m
11	3.9	2.4	1.5	1.6	m
12	3.7	2.2	1.5	1.5	m
13	3.7	2.2	1.5	1.4	m
14	3.7	1.8	1.8	1.0	M
15	3.7	2.7	0.9	3.0	sm
16	3.6	2.1	1.5	1.4	m
17	3.4	1.8	1.5	1.2	m
18	3.3	1.7	1.6	1.1	m
19	3.1	1.8	1.3	1.4	m
20	3.0	1.9	1.1	1.7	m

D) *L. revoluta*- Tesfaye Awas 1159, 2n = 44

Chromosome pairs	tl	l	s	r	Centromere position
1	6.6	5.1	1.4	3.6	st
2	6.2	5.0	1.2	4.1	st
3	6.1	5.0	1.1	4.7	st
4	5.5	4.1	1.4	2.9	sm
5	5.4	4.2	1.2	3.3	st
6	4.8	3.5	1.3	2.7	sm
7	4.8	3.4	1.4	2.5	sm
8	4.2	2.7	1.5	1.8	sm
9	4.1	2.6	1.4	1.8	sm
10	3.9	3.0	0.9	3.2	St
11	3.9	2.4	1.5	1.7	M
12	3.7	2.2	1.5	1.4	M
13	3.3	1.9	1.4	1.4	M
14	2.9	2.0	9.0	0.2	sm
15	2.9	1.9	1.0	1.9	sm
16	2.7	1.5	1.2	1.3	M
17	2.7	1.6	1.1	1.5	M
18	2.6	1.5	1.2	1.2	M
19	2.5	1.3	1.2	1.1	M
20	2.5	1.4	1.1	1.3	M
20	2.5	1.5	1.1	1.4	M
21	2.4	1.3	1.1	1.2	m

Appendix 7. Descriptions of the species under the genera *Drimiopsis* and *Ledebouria.*

1. ***Drimiopsis* Lindl. and Paxt.**

1.1 *D. spicata* (Bak) Sebsebe and Stedje (1195)

Basionym: *Scilla spicata* Baker in Journ. Bot. 1878: 323 (1878). Type: The Sudan, Jur, east of the river Wau, Schweinfurth 1652 (K syntype). Synonym: *Drimiopsis barteri* sensu Stedje, non Baker, in Flora of Ethiopia and Eritrea **6**: 139 (1997).

Plants up to 30 cm long. Leaves Lanceolate, *c* 14 x 3 cm, commonly three in number, with a psuedopetiole of up to 3 cm long. Peduncle *c* 18 cm long, commonly one per plant. Inflorescences dense spike, *c* 8 cm long having *c* 35 flowers. Perianth segments purplish to bluish, 2-2.5 mm long.

Distribution: WG, IL (Ethiopia), Sudan.

Habitat: The species grows in grassland at the margin of *Combretum terminalia* woodland, in annually flooded meadows near riverbanks; 760-1530 m.

1.2 *D. boryoides* Baker (1870)

Type: Africa Orientalis, Sine Loc., Blackburn s.n. (K holo.)

D. erlangeri Dammer (1905)_ type: SD, Marta, Ellenbeck 2043; SD/BA, Genale, Ellenbeck 2081 (Bsyn.).

Plants up to 48 cm long. Leaves broadly lanceolate, *c* 25 x 7 cm. Pseudopetiole up to 8 cm. Peduncle mainly 2 in number, *c* 36 cm long. Inflorescence spicate, up to 10 cm long having *c* 32 flowers. Perianth segments *c* 2 x 2.6 cm, outer perianth segments spreading, inner perianth segments erect with connivent tips, usually wider than the outer.

Distribution: WG, 3 km from Assosa (Ethiopia), Somalia, Uganda, Kenya, Tanzania, West wards to Gahanna and Nigeria.

Habitat: Rocky out crops; *c* 1600 m.

1.3 *D. botryoides* sensu Stedje, non Baker, in Flora of Ethiopia and Eritrea **6**: 140 (1997)**.**

Plants up to 30 cm long. Leaves with very short pseudopetiole and commonly sessile, cordate, mucronate, *c* 11 x 9 cm, usually two in number and the inner one curls and clasps the leafless scape. Peduncle *c* 20 cm in length, commonly one or two per plant. Inflorescence spike, *c* 5 cm long, having *c* 14 flowers. Perianth segments yellow, *c* 2. 5 mm long, outer perianth segments spreading, inner perianth segments erect with connivent tips, usually wider than the outer. The perianth segments of the herbarium materials used here were a little bit damaged further studies recommendable.

Distribution: Benishengul Gumuz (WG): Mechi and Ebicha (Kemashi wereda), Konoch (Sirba Abay Wereda) (Ethiopia).

Habitat: The plants mainly grow on rocky outcrops, cultivated lands, and in open meadows; 820-1165 m

Remarks: The materials belonging to the taxon are identified as *D. botryoides*, but seem to be some other distinct taxon. Further investigation about its identity is recommended.

2. *Ledebouria* Roth

2.1 *L. somaliensis* (Baker) Stedje and Thulin (1995)

Scilla somaliensis *Baker (1892)-Type: Somalia, Ahl mountains, near Meid, Hildebrandt 1470 (K holo.). Drimia colae Baker (1897)- Type: Somalia, Borau, malkare, Ellenbeck 2150a (B holo).*

Plants robust, up to 30 cm long. Leaves cuneate, acute, lanceolate to broadly lanceolate, *c* 11 x 3 cm, commonly 4-5 in number. Pseudopetiole *c* 2 cm. Peduncle *c* 16 cm, 1-5 in number. Inflorescence 9-20 cm long, relatively lax with up to about 45-75 flowers. Pedicels *c* 1-3 mm long, rarely grows to 4 mm long. Perianth segments green to purple, *c* 9-11 mm long, *c* 1.2-2 mm wide, reflexing for larger part. Filaments filiform, usually purple, *c* 7-11 mm long. Ovary *c* 1.5 mm long. Capsule *c* 8 mm long. Seeds *c* 5 mm long.
Distribution: Borana lowland or SD and HA (Ethiopia), Somalia and Kenya.
Habitat: On Acacia woodland, bushland, on sandy or rocky ground; 300-1350 m

2.2 *L. kirkii* (Baker) Stedje and Thulin (1995)

Scilla kirkii Baker (1873)-type: Tanzania, Zanzibar, Kirk 66 (K holo). *Drimia hildebrandtti* Baker (1892)-type: Kenya, Mombasa, Hildebrandt 2001, 2017 (B syn.). *Urginea corradii* Chiov. (1951)-type: Somalia, Baidoa, Corradi 4632 (FT holo.).

Plants up to 40 cm long. Leaves cuneate, acute, lanceolate to broadly lanceoltate, *c* 16 x 4 cm with a pseudopeetiole of *c* 6 cm long. Peduncle *c* 17 cm long, 1-2 in number. Inflorescence *c* 11 cm long, relatively lax having *c* 38 flowers. Pedicels 6-18 mm long. Perianth segments greenish *c* 9-11 mm long, *c* 1.6 mm wide. Filaments filiform, purple, *c* 7 mm long. Ovary *c* 1.5 mm long. Capsules and seeds of similar in nature to that of *L. somaliensis* (Stedje, 1997).
Distibution: SD, Boran and Omo National park, (Ethiopia), Kenya and Tanzania.
Habitat: Shrubland, grassland, woodland on alluvial soil; 350-470 m.

2.3 *L. uroceolata* Stedje (1995)

Type: BA, 8.4 km W of Goro, Nordal 2297 (O holo.)

Plants *c* 13 cm long. Leaves cuneate, acute, narrowly lanceolate, 9 x 2 cm, usually 2-4 in number having a pseudopetiole of *c* 4 cm long. Peduncle *c* 9 cm long, usually 1-3 in number. Inflorescences 3-9 cm long, moderately dense with up to 4 flowers. Pedicels 4-7 long; Perianth segments *c* 5 x 2 mm. Filaments filiform, *c* 5 mm long. Capsule *c* 5 mm long.

Distribution: GJ, SU, BA (Ethiopia)

Habitat: On rocky outcrops mainly on river banks and grassland on thin soil; 2500-2750 m

2.4 *L. cordifolia* (Baker) Stedje and Thulin (1995)

Scilla cordifolia Baker (1898)- Type: Malawi, Shire highlands, Buchanan 194 (K holo). *Eriospermum somliensis* Schinz (1896), non *Ledebouria somaliensis* (Baker) Stedje and Thulin-Type: HA, Abdallah, Keller 172 (Z holo.).

Plants c 20 cm long. Leaves cordate, usually mucronate, usually narrowed in to petiolate; Petiole *c* 4 cm long; Leaf blade *c* 9 x 6 cm, often covered by purple papillae on the upper surface, commonly either one or two in number, clasp the scape (the inner one in case of two leafed plants). Peduncle *c* 14 cm long, commonly 1-3 in number. Inflorescence up to 8 cm long with *c* 50 flowers. Pedicels 5-7 mm long. Perianth segments purple, *c* 6 x 1.2-2 cm. Filaments filiform, 4-5 mm long.

Distribution. BA, on the roadsides from Robe to Sof Umer cave (Ethiopia), Somalia, Kenya, Tanzania, Malawi, Zambia and Angola

Habitat: Grassland, bushy woodland; 1640-2025 m.

2.5 *L.revoluta* (L.f) Jessop (1970).

Hyacinthus revolutus L.f. (1872)-Type: Cape, Thunberg s.n. (UPS holo.) *Ledebouria Hyacithna* Roth (1872); *Scilla indica* Baker (1870) non. Illegit; *Scilla Hyacithina* (Roth) Macbride (1918)

Plant small to relatively robust 17-30 cm long. Leaves narrowly to broadly lanceolate, cuneate, acute, c 10 x 3 cm, often covered with purple spots or lines, 2-7 in number. Psuedopetiole 1-6 cm. Peduncle 7-17 cm long, *c* 1-3 in number. Inflorescence 3-10 cm long, relatively lax to dense with *c* 23-81 flowers. Pedicels 3-7 mm long. Flowers greenish to purple. Perianth segments 3-7 mm long, 1-2 mm wide. Filaments filiform, 3-7 mm long. Capsule *c* 5mm long.

Distribution. EE EW GD GJ SU WG IL SD BA HA (Ethiopia), Somalia, Uganda, Tanzania and Wide spread in tropical regions, in South Africa, in India and Sri Lanka.

Habitat: On Acacia woodland, dense bushland on red soil, in open areas and overgrazed grassland; 600-2300 m.